MAY 1953

Journal

VOL. 45 • NO. 5

AMERICAN WATER WORKS ASSOCIATION

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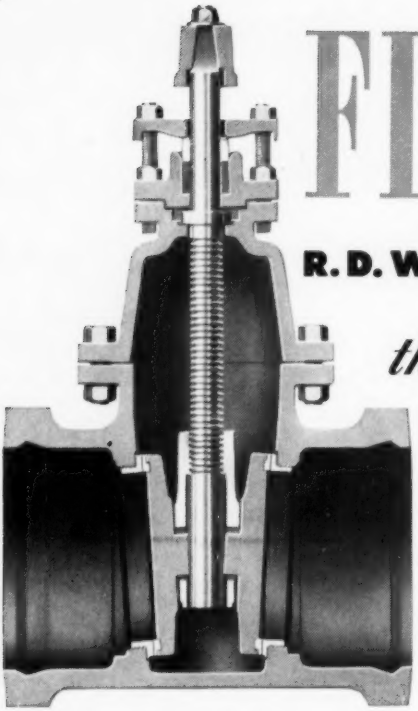

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Journal

AMERICAN WATER WORKS ASSOCIATION | **May 1953**

Vol. 45 • No. 5

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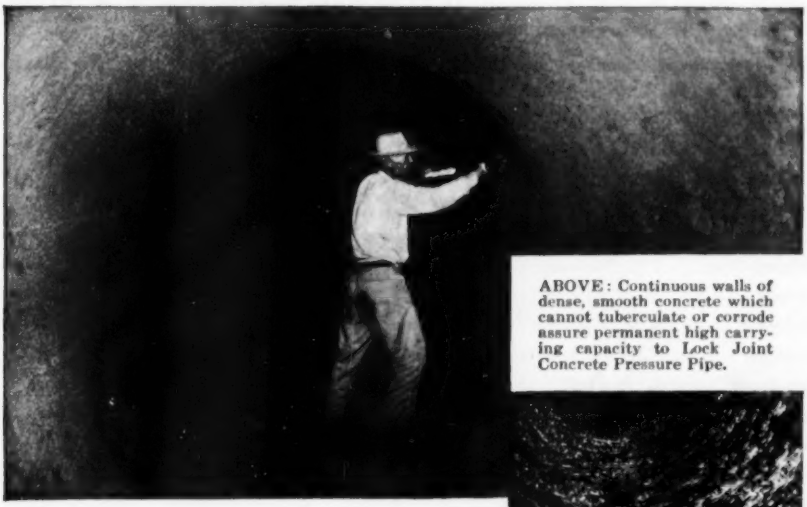
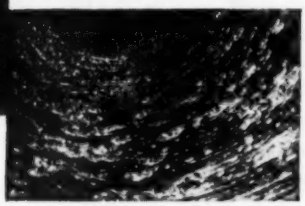


ABOVE: Continuous walls of dense, smooth concrete which cannot tuberculate or corrode assure permanent high carrying capacity to Lock Joint Concrete Pressure Pipe.



ABOVE: The tuberculated condition of this metallic pipe reduces its carrying capacity 50%.

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PIPE LINE CREWS encounter all kinds of conditions from deep woods to the congested streets in the heart of a large city's business district. This cast iron pipe installation could be either a water supply line from a mountain reservoir or a sewer force main leading to a remote treatment plant. If it were a gas transmission line it would, of course, be mechanical joint pipe.

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June 17–19—Pennsylvania Section at Hershey Hotel, Hershey. Secretary, L. S. Morgan, Div. Engr., State Dept. of Health, Greensburg.

Sept. 3–4—West Virginia Section at Hotel Morgan, Morgantown. Secretary, Harry K. Gidley, Director, Div. of San. Eng., State Dept. of Health, Charleston.

Sept. 1–5—Minnesota Section at Royal Alexandria Hotel, Winnipeg. Secretary, Leonard N. Thompson, Gen. Mgr., Water Dept., St. Paul, Minn.

Sept. 3–4—Michigan Section at Escanaba. Secretary, T. L. Vander Velde, Chief, Sec. of Water Supply, State Dept. of Health, Lansing.

Sept. 10–11—New York Section at Lake Placid Club, Lake Placid. Secretary, R. K. Blanchard, Neptune Meter Co., 50 W. 50th St., New York 20, N.Y.

Sept. 10–11—Ohio Section at Hotel Cleveland, Cleveland. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington.

Sept. 21–23—Kentucky-Tennessee Section at Hotel Owensboro, Owensboro. Secretary, J. Wiley Finney, Jr., Asst. Director, State Dept. of Public Health, 420 6th Ave., N., Nashville 3, Tenn.

Sept. 22–23—Rocky Mountain Section at LaFonda Hotel, Sante Fe. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

Sept. 22–24—Wisconsin Section at Hotel Pfister, Milwaukee. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

Sept. 27–29—Missouri Section at Elms Hotel, Excelsior Springs. Secretary, Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

OTHER ORGANIZATIONS

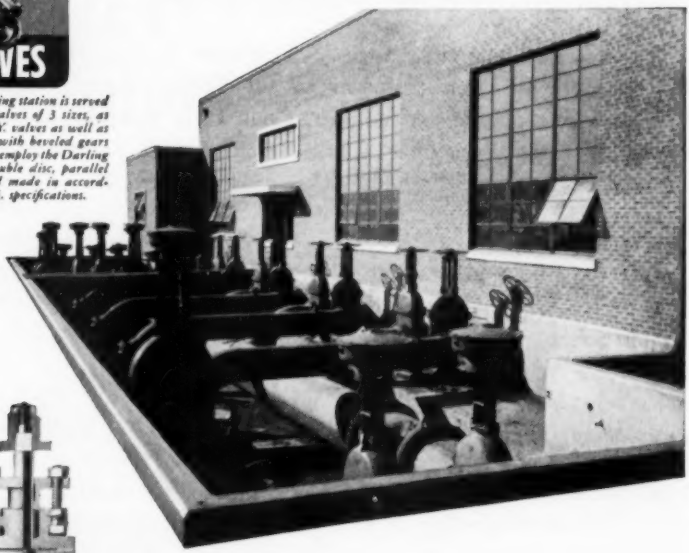
May 11–15—National Fire Protection Assn., Palmer House, Chicago. Details from Percy Bugbee, Gen. Mgr., 60 Batterymarch St., Boston, Mass.

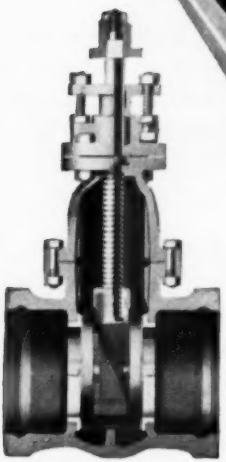
(Continued on page 12)

DARLING VALVES

FOR PLUS VALUES, JOB-PROVED AGAIN AND AGAIN

This modern pumping station is served by Darling gate valves of 3 sizes, as shown—20" O.S.&Y. valves as well as 30" and 36" sizes with beveled gears and gear cases. All employ the Darling fully revolving, double disc, parallel seat principle, and made in accordance with A.W.W.A. specifications.





Note rugged simplicity of this unique Darling principle—just four sturdy working parts . . . two plain interchangeable no-pocket discs and two husky wedges. Assembly and maintenance is extremely easy and foolproof.

Time and money ahead

THIS new municipal pumping station gains a unique advantage proved in hundreds of similar operations throughout the country. Because these gate valves are Darlings . . . *featuring Darling's fully revolving, double disc, parallel seat principle* . . . the city as well as the water department will be time and money ahead years on end.

If you haven't yet checked into Darling gate valves of this type (shown in cutaway view at left) we'd like to give you *all* the facts on the distinctive features that always add up to . . .

1. Positive, easier closing. 2. Automatic adjustment for valve body distortion. 3. Elimination of disc-to-seat galling. 4. Uniform wear distribution. 5. Greater service life with far less maintenance.

SEND FOR BULLETIN

Darling's latest bulletin is full of helpful information and describes Darling valves of *all* types for every normal or unusual service.

DARLING VALVE & MANUFACTURING CO.

Williamsport 23, Pa.

Coming Meetings

(Continued from page 10)

May 12–14—American Public Power Assn., Sheraton Plaza Hotel, Boston. Details from Alex Radin, Gen. Mgr., 1757 K St., N.W., Washington 6, D.C.

May 31–June 4—Municipal Finance Officers Assn., Hotel McAllister, Miami. Details from Joseph F. Clark, Director, 1313 E. 60th St., Chicago 37, Ill.

June 15–19—Gordon Research Conference on Ion Exchange, AAAS, New Hampton School, New Hampton, N.H. Details from W. George Parks, Director, Dept. of Chemistry, Univ. of Rhode Island, Kingston, R.I.

June 16–19—Spring Technical Meeting and Welding Exposition of American Welding Society at Shamrock Hotel, Houston, Tex. Details from Society at 12 E. 41st St., New York 17, N.Y.

June 16–19—American Welding Society Exposition at Shamrock Hotel Hall of Exhibits, Houston, Tex. Details from AWS at Rm. 1006, 12 E. 41st St., New York 17, N.Y.

June 21–27—Congres International de Chimie Industrielle, Paris, France. Details from Societe de Chimie Industrielle, 28, Rue Saint-Dominique, Paris VII, France.

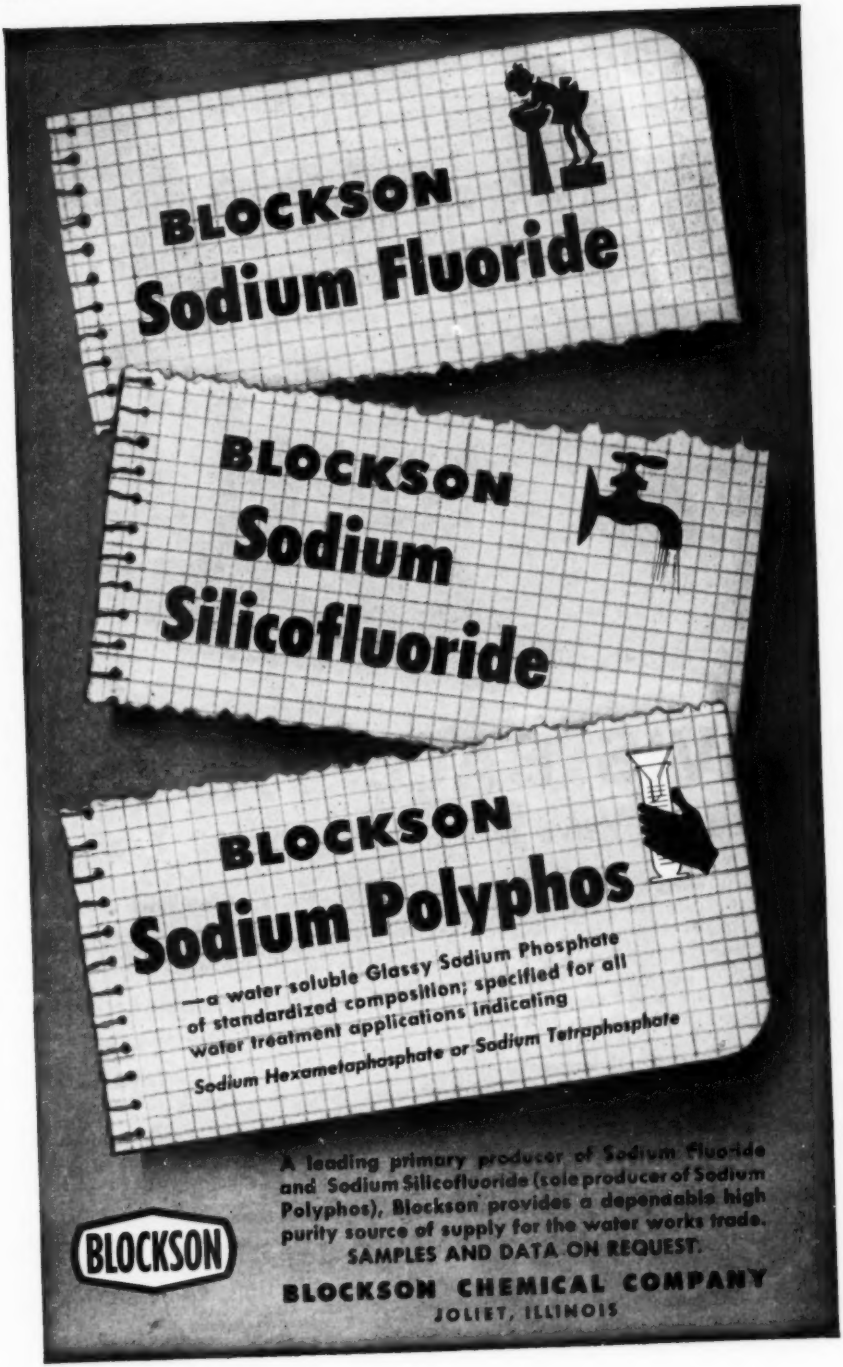
June 29–July 3—American Society for Testing Materials, Chalfonte-Haddon Hall, Atlantic City, N.J. Details from Robert J. Painter, Exec. Secy., 1916 Race St., Philadelphia 3, Pa.

Sept. 28–30—New England Water Works Assn., Poland Spring House, Poland Spring, Me. Details from Joseph C. Knox, Secy., 73 Tremont St., Boston 8, Mass.

Oct. 8–9—National Conference on Industrial Hydraulics, Sheraton Hotel, Chicago. Details from Otmar E. Teichman, Conference Director, Illinois Inst. of Technology, 35 W. 33rd St., Chicago 16, Ill.

Oct. 13–16—Federation of Sewage and Industrial Wastes Assns., Municipal Auditorium, Miami, Fla. Details from W. H. Wisely, 325 Illinois Bldg., Champaign, Ill.

Oct. 26–29—American Public Works Assn., New Orleans, La. Details from D. F. Herrick, Exec. Secy., 1313 E. 60th St., Chicago 37, Ill.


BLOCKSON
Sodium Fluoride
BLOCKSON
Sodium
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BLOCKSON
Sodium Polyphos
—a water soluble Glassy Sodium Phosphate
of standardized composition; specified for all
water treatment applications indicating
Sodium Hexametaphosphate or Sodium Tetraphosphate
A leading primary producer of Sodium Fluoride
and Sodium Silicofluoride (sole producer of Sodium
Polyphos), Blockson provides a dependable high
purity source of supply for the water works trade.
SAMPLES AND DATA ON REQUEST.
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BLOCKSON CHEMICAL COMPANY
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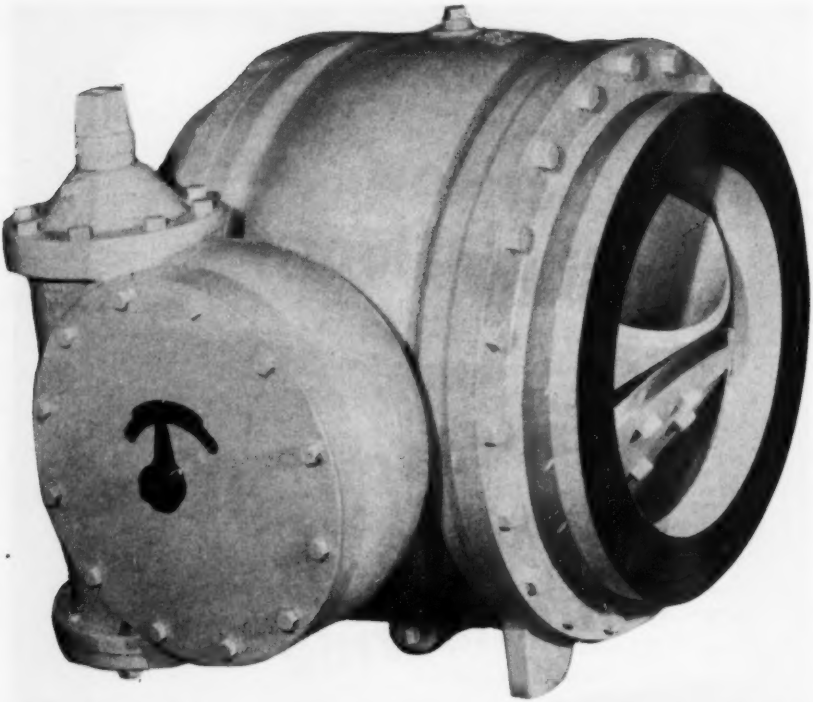


DAVIS BALL VALVES

Greatest Valve Development in 42 Years!

Davis Ball Valves for water and sewage are as economical to purchase and install as ordinary gate valves . . . but what an improvement! Far easier to close because the plug acts as a water wheel and the operating mechanism has variable leverage. Amazingly simple design. Exceptionally rugged. Smaller, lighter than other rotary valves of equal capacity. Totally enclosed mechanism. Minimum loss of head, the same as an equal length of pipe. Tightest of any valve. Manual, electric or hydraulic operation. All sizes from 6" to 54". Proved in use by leading municipalities. Write for catalog.

- ✓ **Stop Valve**
- ✓ **Automatic Stop and Check**
- ✓ **Pressure Regulation**
- ✓ **Altitude Valve**
- ✓ **Emergency Line Check**
- ✓ **Float Operation**

See our Exhibit—Booths 78–79 AWWA Convention—Grand Rapids

DAVIS MANUFACTURING CO.

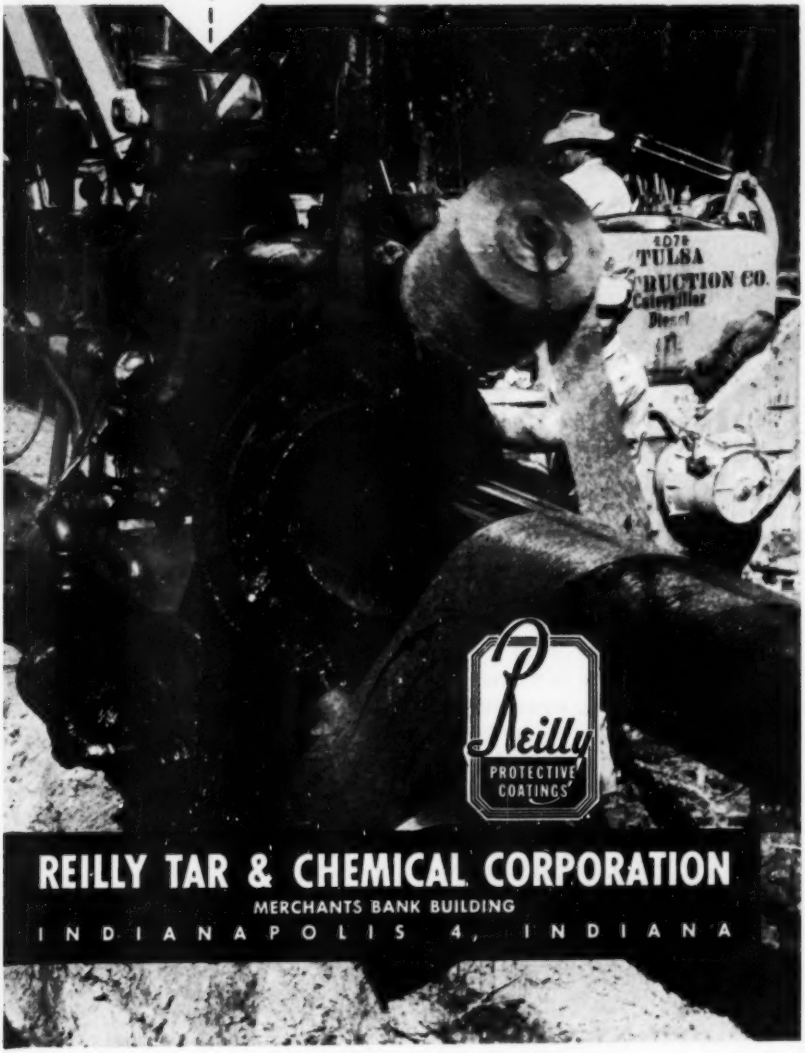
321 N. Maple Drive Beverly Hills, California

Representatives in all principal cities

Reilly

FIELD SERVICE IS YOURS FOR THE ASKING

Reilly Tar and Chemical Corporation maintains a staff of practical corrosion engineers who are available for consultation on your coating problems. These men are widely experienced in enamel application . . . and go into the field to assist in applying Reilly enamel to make sure that you get longer, lasting protection.



CORROSION-RESISTANT GATES:

FABRICATED OF EVERDUR, THEY WEIGH LESS

Sewage control gates of Everdur* Copper-Silicon Alloys combine corrosion resistance with light structural weight for easier operation.

Available in all the usual wrought structural forms such as sheet, plate, angles, channels, rods, tubes and electrical conduit, Everdur is easy to fabricate to any design and specification by conventional welding and machining techniques. According to the particular Everdur Alloy, it may also be worked hot or cold, forged or cast.

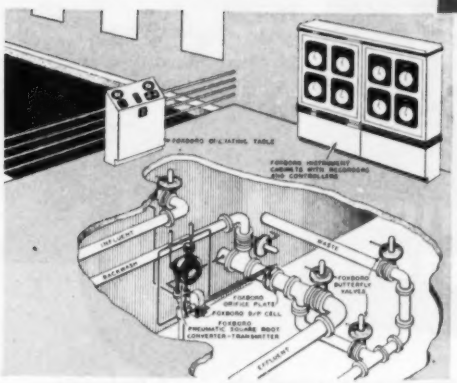
Everdur structural equipment, in addition to lighter weight, possesses strength characteristic of these tough, corrosion-resistant alloys. These properties suggest the suitability of Everdur for gate guides, bolts, valve and gate stems, weirs, float chambers, troughs and manhole steps. You'll find detailed data in "Everdur for Sewage Treatment and Waterworks Equipment." We should like to send you a copy and to offer our Technical Department's services in selecting the best material for your equipment. Write to *The American Brass Company, Waterbury 20, Connecticut. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario.* 53137 A

*Reg. U. S. Pat. Off.

EVERDUR
ANACONDA®
COPPER-SILICON ALLOYS
STRONG • WELDABLE • WORKABLE
CORROSION-RESISTANT

Fingertip Control

for rapid sand filters



An automatic Foxboro Rapid Sand Filter Control System

..a new, exclusive system that's easier to install, operate, and maintain

The new Foxboro Rapid Sand Filter Control System combines maximum operating convenience with a minimum of maintenance. Its all-pneumatic transmission and control eliminates drums, cables, and pulleys . . . makes possible remote operation of valves *without* high pressure piping to the control panel.

In normal operation, the operator needs only to turn the selector switch to one of its four positions to control: filtering; influent-off; backwashing; effluent-to-waste. Also, all adjustments of filtering and backwashing rates are easily made at the operating table.

All connections made with ¼" copper tubing. Hence, installations with remote setting of flow rates — and with supplementary remote indication — are simple and economical.

Write for Bulletin 466. **The Foxboro Company, 165 Norfolk Street, Foxboro, Mass., U.S.A.** Branch offices in principal cities.

FOXBORO Reg. U. S. Pat. Off. **CONTROL SYSTEMS**

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

A complete line of Water Works products . . . Conforms to *all* AWWA Standards . . . Quality that comes from over 80 years' manufacturing experience . . . Fittings interchangeable with other makes . . . Corporation stops can be installed with any standard tapping machine equipment.

Write for literature, or ask "The Man from Hays"

HAYS

Water Works Products

HAYS MANUFACTURING CO.

ERIE, PA.

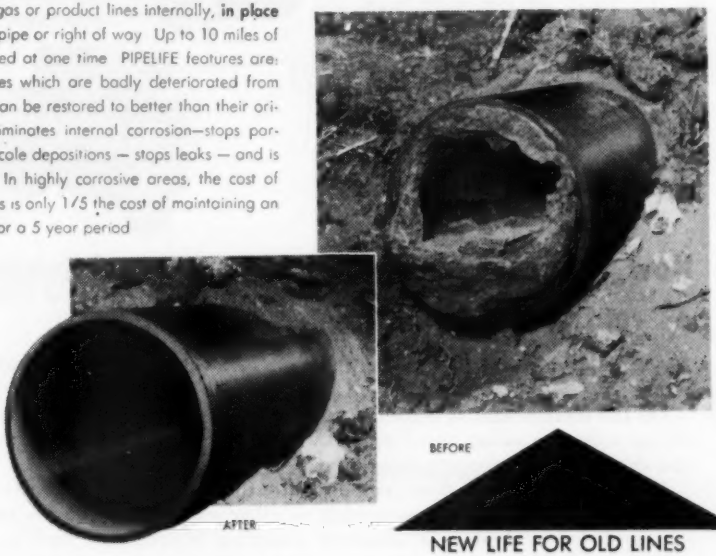
"PIPELIFE"

CLEANS AND PLASTIC COATS LINES INTERNALLY IN PLACE

NOTICE

Increasing demand for Pipelife necessitates national expansion. A limited number of exclusive territories are open to qualified prospective licensees. Call or write Pipelife, Inc., Box 1711, phone 6-3774, Odessa, Texas.

Reclaim old pipe—protect new pipe with PIPELIFE! Here is a field proven, patented method of cleaning and plastic coating oil, water, gas or product lines internally, **in place** without damage to pipe or right of way. Up to 10 miles of line can be processed at one time. PIPELIFE features are: Old condemned lines which are badly deteriorated from internal corrosion, can be restored to better than their original efficiency. Eliminates internal corrosion—stops paraffin build-up and scale depositions — stops leaks — and is economical to use. In highly corrosive areas, the cost of applying this process is only 1/5 the cost of maintaining an uncoated new line for a 5 year period.



BEFORE

AFTER

NEW LIFE FOR OLD LINES
LONG LIFE FOR NEW LINES
MORE LIFE FOR ALL LINES

POSITIVE PIPELINE PROTECTION

The PIPELIFE process offers positive protection for both old and new lines. Pipelines, in areas where internal corrosive elements limit their life expectancy to approximately three years, can be protected for almost unlimited years of service with PIPELIFE protection. Up to 10 miles of line can be cleaned and plastic coated internally, in place (underground), without damage to pipe or right-of-way. To date, OVER A MILLION FEET of line have been PIPELIFE processed. This represents a definite trend by companies to conserve lines in the face of pipe shortage.

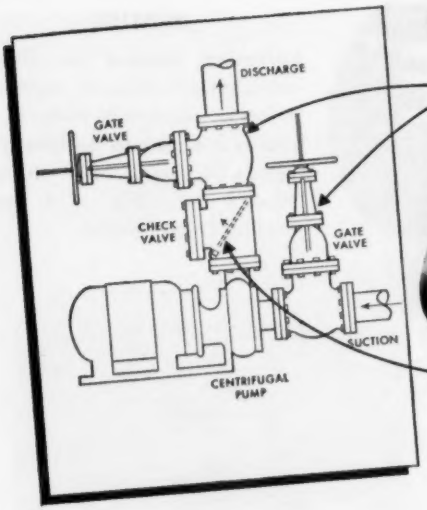
No line is too difficult to clean and process the PIPELIFE way. Above are actual photos of a 6-inch vacuum gas line, located in New Castle, Wyoming, before and after being cleaned and plastic coated (in place) by PIPELIFE, INC., Odessa, Texas. Write or phone today for a free folder explaining the process in detail.

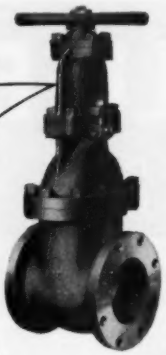
PIPELINES CLEANED AND PLASTIC COATED INTERNALLY — IN PLACE

INTERNAL PIPELINE MAINTENANCE

PIPELIFE, INC.

BOX 1711 ODESSA, TEXAS 1604 W. 2ND





KENNEDY Fig. 0611 iron-body bronze mounted gate valve with solid wedge disc.

KENNEDY Fig 106 swing check valve. Iron-body, bronze-mounted. Available with bronze, leather or iron discs.

How proper valving assures easy maintenance of centrifugal pumping systems

In the diagram, you will note that there is a *gate* valve on either side of the pump.

On the suction side, it is connected directly with the pump. On the discharge side, the *swing check* valve should be located between the pump and the *gate* valve.

With this set-up, the flow can be readily shut off between the two gate valves to provide fast, easy repacking or other maintenance on the pump or check valve. And in a multiple pumping system, any one of the pumps can be shut down while the others continue to operate.

KENNEDY **JOB-FITTED** **iron-body gate and swing check valves** are ideally suited to this application. They are designed and constructed for heavy-duty service with water, oil, gas or any fluids that will not corrode bronze or iron. The rising stem on the KENNEDY outside screw and yoke gate valves tells whether valves are open or closed. KENNEDY swing check valves have readily removable cap for easy inspection or adjustment.

THE COMPLETE LINE OF KENNEDY JOB-FITTED valves and INSPECTED fittings is sold through local distributors, ready to give you fast and convenient service.

Est. 1877

THE **KENNEDY**

VALVE MFG. CO. • ELMIRA, N.Y.

VALVES • PIPE FITTINGS • FIRE HYDRANTS

TRENCH POURED

BELL & SPIGOT JOINTS

Specify McWANE-PACIFIC CENTRIFUGAL PIPE

So, you like to pour your own joints! OK! Trench-poured joints have been a stand-by for close to two centuries. Many thousands of miles of cast iron pipe line with this old stand-by joint have long been in service. Specify McWane-Pacific Super DeLavaud Cast Iron Pipe, in 18-foot lengths. Bells and spigots are uniform, make better trench-poured joints. The pipe is strong, easy to cut and tap. For complete data and prices, write or wire.

McWANE Cast Iron Pipe Company
Birmingham, Ala.
Pipe Sizes 2" thru 12"

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Dallas 4, Texas	3200 Maple Avenue

PACIFIC STATES Cast Iron Pipe Co.
Provo, Utah
Pipe Sizes 2" thru 24"

Sales Offices

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WATER Paces Gary's Business Growth!

Allis-Chalmers Helps Indiana's Fastest

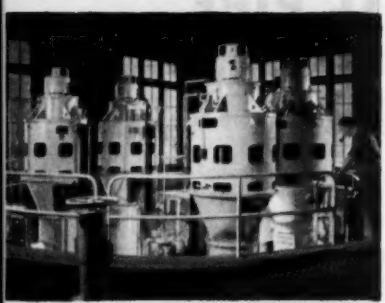
INDIANA'S FASTEST GROWING CITY knows that an adequate water supply is necessary for future growth. Gary, one of America's few planned cities, has zoomed to its present 135,000 population (Indiana's second greatest) in less than 50 years.

And planning for a still bigger future, Gary recently installed these Allis-Chalmers pumps and motors to create capacity adequate for population *doubling!* With over 123 local industries — including the world's largest complete steel mill, sheet and tin mill, and cement plant — Gary is wise to allow for plenty of future growth.

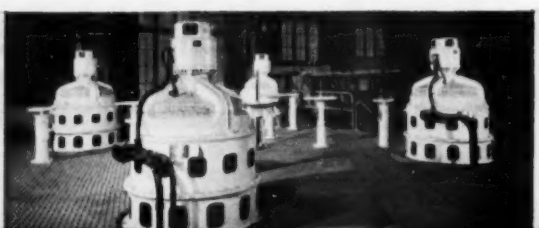
The Gary-Hobart Water Corporation operation also is unusual in that all city water comes through a Lake Michigan suction tunnel 6 ft in diameter and *three miles long.* When power fails, this moving column of water can cause a surge flooding the main pumping station.

With the original horizontal pumping units, a surge rendered motors inoperative for some time. The four new Allis-Chalmers vertical mixed flow units were made 57 ft long so that the impellers are kept submerged despite "draw down" and yet the 350 hp motors cannot be flooded. Fifteen foot extensions protect the motors for the four high head units.

When *your city* plans expansion or modernization, do as Gary and other leading cities are doing — take advantage of Allis-Chalmers experience in municipal pumping equipment. Ask for Pump Bulletin 08B6146A, containing 24 pages fact-packed with the kind of engineering data you'll want to keep handy. Just call your nearest A-C sales office or write to Allis-Chalmers, Milwaukee 1, Wisconsin. A-3994

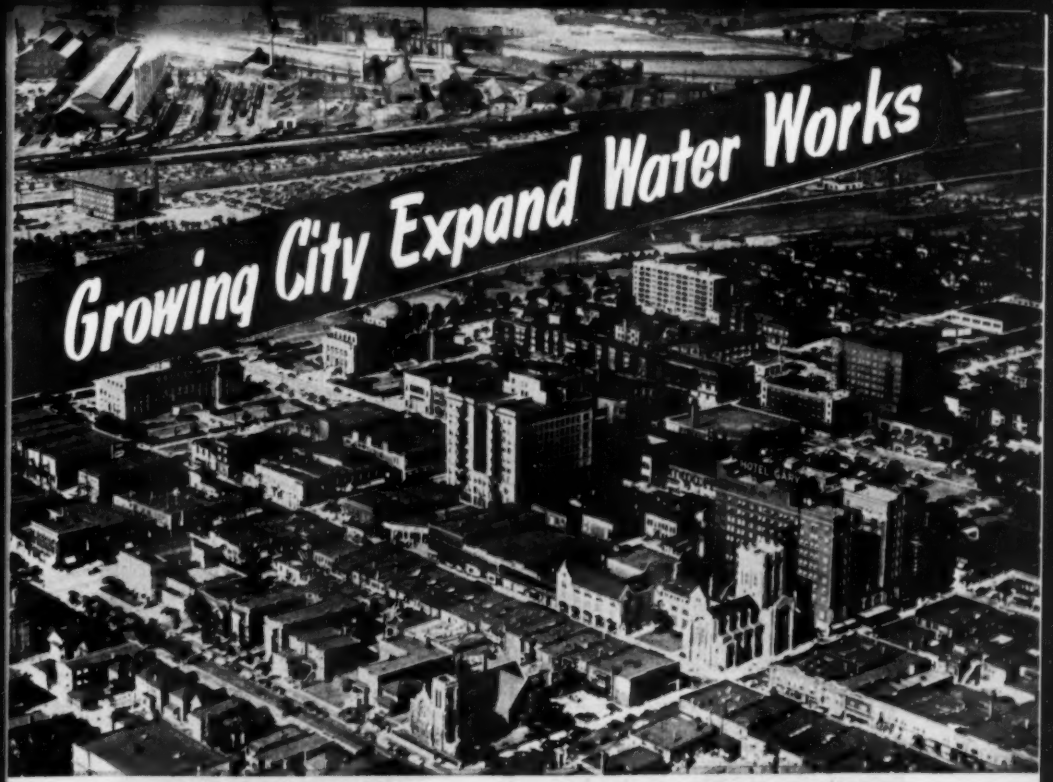


LOW LIFT PUMPS in the 100 ft deep well at tunnel's end are 36 x 24 in. mixed flows, each rated 15,000 gpm against 50 ft head; driven by 350 hp, 720 rpm synchronous motors. Units were made 57 ft long to avoid motor flooding in case of power failure. In 1951, Gary's peak pumpage rate for one hour was 44 M.G.D.

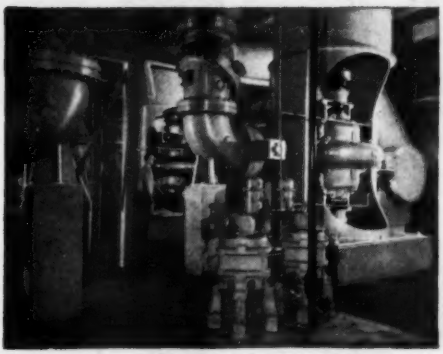


HIGH HEAD PUMPS are 24 x 18 in. centrifugals, each rated 14,000 gpm against 160 ft head; driven by 700 hp, 720 rpm synchronous motors. The high head units pump directly into the mains, operating in series with the mixed flow pumps. Special 15 ft high barrel type supports keep the motors out of flooding danger.

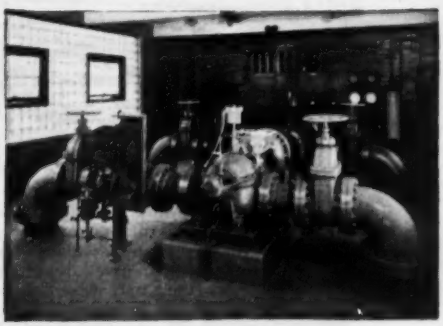
Growing City Expand Water Works



METROPOLITAN GARY, the planned city built on the sand dunes at the lower end of Lake Michigan. Portions of steel mills and lake are seen in distance.



GREAT FLEXIBILITY at the main pumping station is provided by the header and valving arrangement. Operation can be varied from only one high head unit in service — pumping directly from well to mains and adequate for light loads — to all eight units pumping simultaneously — adequate for Gary population doubling.



GLEN PARK BOOSTER STATION is also exclusively Allis-Chalmers. These two 12 x 12 in. centrifugal pumps are each rated 3200 gpm against 115 ft head; driven by 50 hp, 1160 rpm induction motors. To maintain constant pressure, they are automatically remote-controlled from the water tower.

ALLIS-CHALMERS

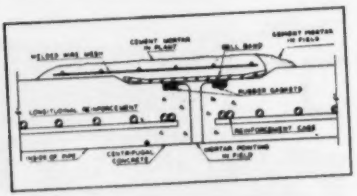
A-C ALLIS CHALMERS

Builders of the World's Widest Range of Public Works Equipment

THIS PIPE CAN SAVE YOU MONEY

HOW . . .

By Specifying Centrifugally Spun Reinforced Concrete Pressure Pipe, with The Double Rubber Gasket Joint, for moderate operating heads. Maximum operating heads range from 100 ft. to 150 ft. depending upon pipe diameter and operating conditions.



A watertight closure, simple in design, flexible and positive in service. Joints may be pulled to allow for minor changes in line or grade. Angle joint bands provided for larger deflections. This joint was developed by American to insure ease and speed of installation.

WHY . . .

1. *FREEDOM FROM MAINTENANCE.*
2. *SUSTAINED MAXIMUM CARRYING CAPACITY.*
3. *EASE OF INSTALLATION.*
4. *PERMANENCE.*
5. *LOW FIRST COST.*

Rely on American Pipe and Construction Company's 45 years of know-how in this field. Our experience, our informative booklets and our sales engineers are as near as your telephone.

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Concrete Pipe for Main Water Supply Lines, Storm and Sanitary Sewers, Subaqueous Pipe Lines

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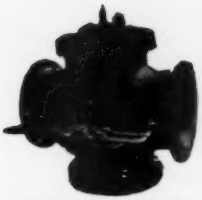
1879—ROSS—1879

Automatic Valves



ALTITUDE VALVE

Controls elevation of water in tanks, basins and reservoirs

1. Single Acting
2. Double Acting

Maintains safe operating pressures for conduits, distribution and pump discharge

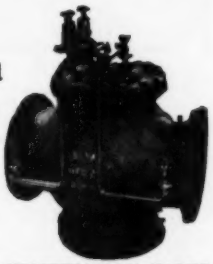
SURGE-RELIEF VALVE

REDUCING VALVE

Maintains desired discharge pressure regardless of change in rate of flow

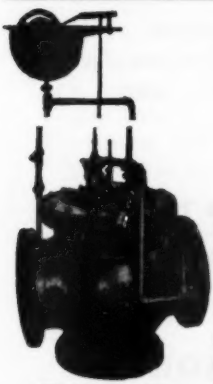
Regulates pressure in gravity and pump systems; between reservoirs and zones of different pressures, etc.

A self contained unit with three or more automatic controls



COMBINATION VALVE

Combination automatic control both directions through the valve.

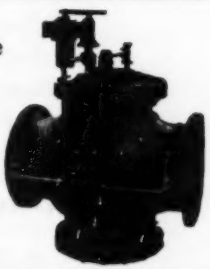


FLOAT VALVE

Maintains levels in tank, reservoir or basin

1. As direct acting
2. Pilot operated and with float traveling between two stops, for upper and lower limit of water elevation.

Electric remote control—solenoid or motor can be furnished



REMOTE CONTROL VALVE

Adapted for use as primary or secondary control on any of the hydraulically controlled or operated valves.

Packing Replacements for all Ross Valves Through Top of Valve

ROSS VALVE MFG. CO., INC., P. O. BOX 593, TROY, N. Y.

Wide World Photo

this could happen in your town

THIS CITY STREET CAVED IN when a water main broke. It's a dramatic, but not an unusual example of what water does to road bedding.

Protect your roads and pipes from the problems of leakage by Centrilining. This patented process thoroughly cleans and centrifugally lines pipes with cement mortar. Leakage, tuberculation and interior corrosion are permanently checked . . . carrying capacity and distribution pressure are increased to "better than new" highs. And the whole process is done with pipes in place . . . no excavation . . . no traffic disruption.

With Centrilining you can save your water mains . . . and streets too.

Write today for free booklet

CEMENT-MORTAR LININGS FOR PIPES IN PLACE

3,000,000 FEET OF EXPERIENCE

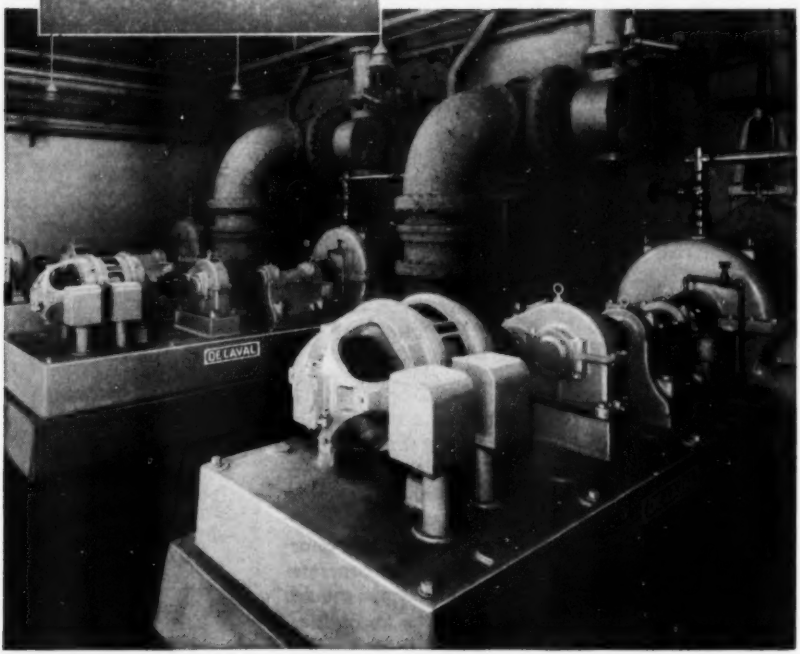
CENTRILINE CORPORATION

A subsidiary of Raymond Concrete Pile Co.

140 CEDAR STREET, NEW YORK 6, N. Y.

Branch Offices in Principal Cities of United States and Latin America

DE LAVAL SEWAGE PUMPS *serve Baltimore's new plant*



Three De Laval sewage pumps are on the job in the City of Baltimore's new Brooklyn Sewage Pumping Station built for today's need and planned for future expansion.

Two of these high efficiency motor-driven horizontal pumps have a capacity of 3,000 gpm and the third a capacity of 7,000 gpm. Later, as flow increases, the two 3,000 gpm units can be replaced by a 7,000 gpm pump.

Slow speeds of these De Laval pumps insure long life, large passageways reduce clogging and nickel-chrome cast iron casings and impellers assure long wear.

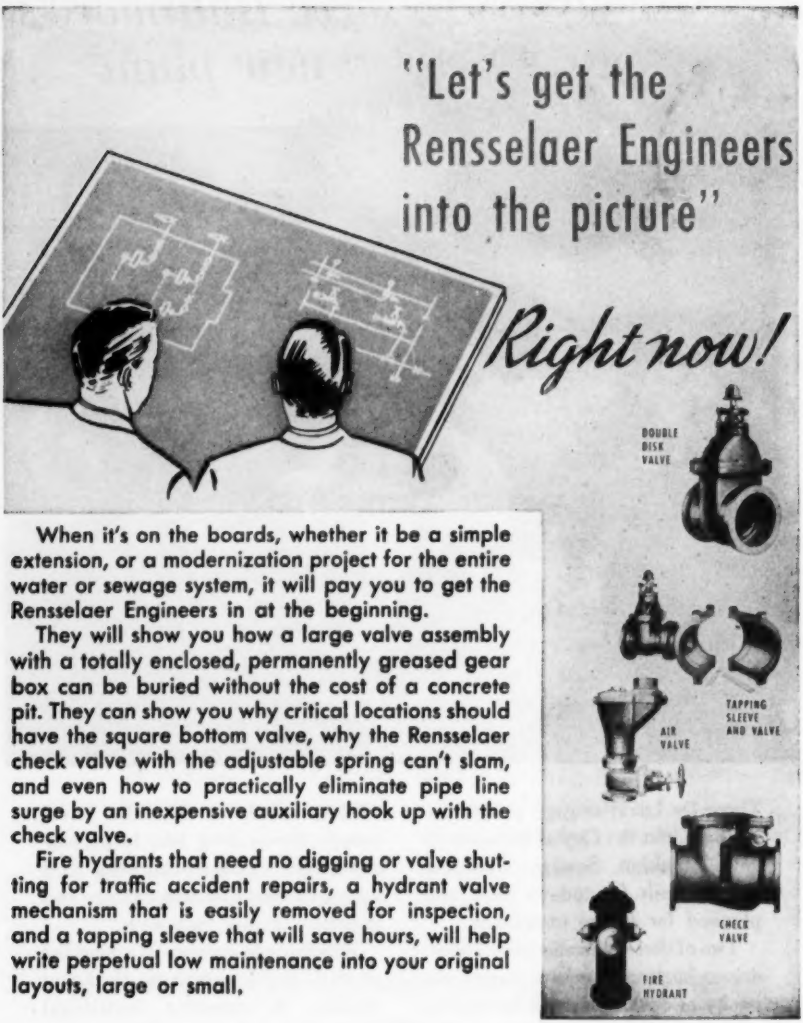
Baltimore is another of a long list of cities being served by De Laval pumps. A complete centrifugal pump line is built on 50 years experience at De Laval — pioneer in the municipal pumping field.

DE LAVAL *Sewage Pumps*

DE LAVAL STEAM TURBINE COMPANY

822 Nottingham Way, Trenton 2, New Jersey

DL 171A



When it's on the boards, whether it be a simple extension, or a modernization project for the entire water or sewage system, it will pay you to get the Rensselaer Engineers in at the beginning.

They will show you how a large valve assembly with a totally enclosed, permanently greased gear box can be buried without the cost of a concrete pit. They can show you why critical locations should have the square bottom valve, why the Rensselaer check valve with the adjustable spring can't slam, and even how to practically eliminate pipe line surge by an inexpensive auxiliary hook up with the check valve.

Fire hydrants that need no digging or valve shutting for traffic accident repairs, a hydrant valve mechanism that is easily removed for inspection, and a tapping sleeve that will save hours, will help write perpetual low maintenance into your original layouts, large or small.

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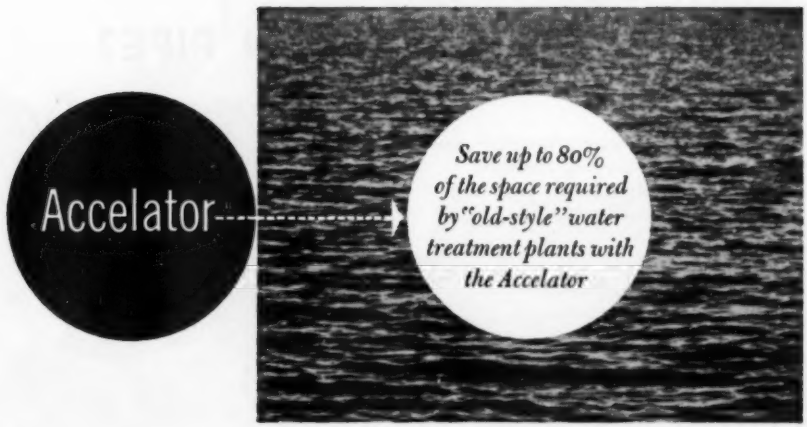

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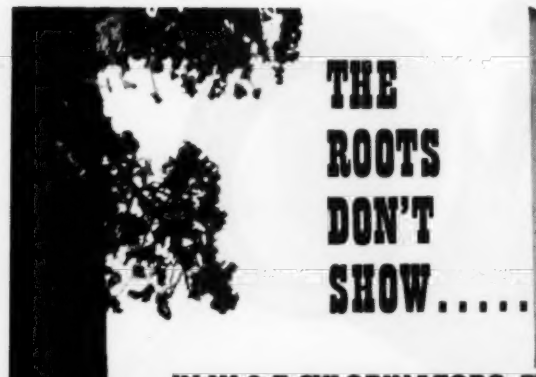

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Field Contacts With the Public

By F. A. McCanlies

A paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by F. A. McCanlies, Asst. Vice-Pres., Southern California Gas Co., Los Angeles.

GOOD public relations may be defined as the act of doing good and getting credit for it. The matter of public relations cannot successfully be delegated to one individual or department. It cannot be a one-man job, but must be the concern of every officer, every foreman, and every employee. In fact, everyone in an organization should be considered a front-line goodwill ambassador.

As a public utility must serve all the people, it has more difficulty in winning and holding the public favor than do most other businesses. Also, because its customers are not entirely free to take their business elsewhere, it has the constant responsibility of making them realize that it is working for their interests and that its service is worth what they pay for it.

This task calls for careful training and retraining of all employees in the techniques of good, friendly customer contacts. Practically all employees in the utility business have some opportunity to deal directly with customers, and employee training in courteous, considerate treatment of the public is just as important as the other aspects of their day to day jobs.

The utility's first concern, of course, is always to give the customer good service. If it is able to provide for his needs in a reasonably satisfactory manner, the utility will have very little to worry about in the way of bad public relations. But the average customer may take the service for granted and form his judgment on the basis of very rare contacts with utility personnel. Consequently, the proper handling of such contacts is of great importance.

Customer contacts may be divided into two categories: direct contacts, in which utility people deal directly with individual customers; and indirect contacts, in which the utility relies on advertising, publicity, and other

means to make itself better known to the public.

Personal Contact

In direct, or person to person, contacts, first impressions are important. The time to start building goodwill is when a customer first calls at the office, or telephones, or writes for service. That is the best opportunity to establish the atmosphere for future cordial relations.

Customers judge a utility upon the appearance of its business offices and, particularly, on whether or not they get considerate treatment from its employees. They are greatly impressed with the reasonableness or unreasonableness of rates and credit policies, and whether it is easy or difficult to get prompt service. In this regard, many utilities no longer require guarantee deposits generally and will take applications by telephone rather than insist on a signed request.

Many utilities also have liberalized their policies on complaint handling. Working on the theory that the customer is almost always right, they give the same prompt attention and follow-up to complaints as they do to collections.

Collectors have one of the most trying jobs in any organization. They must, of course, bring in the money, but they have an excellent opportunity as goodwill builders if they are properly schooled in the techniques of sound customer relations. Their firm approach can be tempered with courtesy and consideration, and, if they must say no, they can usually make it a friendly no.

Servicemen and troubleshooters, too, have an exceptional opportunity to create goodwill for the company. Like the collector and complaint man, every contact they make is the result of some difficulty or inconvenience to a customer who needs help. When help is given in a courteous, friendly manner, the utility reaps the benefits of everlasting goodwill.

These points are so familiar that it is unnecessary to dwell on them further in this paper. It can be mentioned with pride, however, that utilities today are constantly striving to make these operations seem more friendly, and it is gratifying to know that their record compares favorably with other businesses in this respect.

Street Relations

There is another area of direct customer contacts, one which involves a great number of customers and which, until recently, received only a minimum amount of attention in public relations thinking. A few years ago a construction or repair man would have been astounded, to say the least, if anyone had suggested that he assume the role of public relations agent. None of that fancy stuff for him! His job was to dig ditches and lay pipe, and that was that. This attitude is a very understandable one, for no one had ever told these operating people that they were expected to play an important part in building customer goodwill. But that picture is changed today. Given the right opportunity and encouragement, field men soon become very enthusiastic about the public relations part of their jobs.

In construction, maintenance, and repair work there are a number of things that affect public relations. A veteran utility superintendent recently said that public relations today is moving out into the streets. Work in

the streets and parkways interferes with the normal routines of people. It makes noise and dust and hinders traffic. Unlike other utility activities, this work does not seem to offer any immediate benefit to the individuals affected. But they see the trucks, obstruction signs, and piles of dirt; and, all too often, they are forced to accept the inconsiderate behavior of field men along with the dust and noise. Out of all this has developed a consciousness of what might be termed "street relations."

The author's firm, the Southern California Gas Co., set out a couple of years ago to learn what was being done, and to get ideas on what should be done, to keep its customers happy, even though it is constantly tearing up their streets and otherwise making itself a general nuisance.

On one particular job the company had an unusual opportunity to try out some public relations ideas and to make a comprehensive appraisal of how people would react to them. This job called for the laying of a 30-in. gas transmission line for a distance of 15 miles through a heavily populated residential section of Los Angeles. It was an unusual job because it was to traverse relatively narrow streets, and it called for the opening of a 4-ft wide trench at depths as great as 20 ft.

This work presented about all the customer relations problems that might ever be expected on a construction job. There were serious problems of earth disposal, streets had to be kept open to traffic, children had to be prevented from interrupting work or getting hurt around the machinery or open trenches, driveways had to be kept open so that householders and business establishments could continue their normal routines. There were countless other temporary inconveniences that could be anticipated and, to some degree, minimized. The engineering department found that many of these problems could be dealt with in the engineering or planning stage. It was decided, for instance, to operate the heavy equipment in small, fast-moving units so that no more than two or three residential blocks would be tied up at a time, and then for only 2- or 3-day periods. Residents were able to use their streets at all times. In other words, the job was planned so that consideration was given to human as well as engineering problems.

People are accustomed to accepting work of this kind as a necessary evil. If a reasonably efficient job is done, the utility can expect at least a neutral reaction from its customers. But here was an opportunity to turn a liability into an asset. If the company could eliminate some of the usual frictions and irritations from this job, it stood a good chance to win the cooperation and enduring goodwill of the people affected.

As the job was to take approximately 5 months to complete, it was decided to assign a man to the task of looking after the interests of customers who lived along the route of the pipeline. A full-time public relations representative advanced ahead of the crews and acted as liaison between pipeliner and householder. His job was to call at every house and business establishment where the crews were to work the following day.

Calling on a typical home, he would introduce himself, state his business, and then learn the family routine. He would carefully note such items as when members of the family left for

school or work, or when the housewife shopped, and whether the family car was used, so that driveways could always be kept open. In emergencies, he arranged for transportation. Noting all facts which might affect the customer's comfort or convenience, he would explain how the job would progress, point out the hazards, and offer to assist in protecting the customer's interests.

Records of each contact were kept to permit a follow-up of unusual situations. Hundreds of individual cases were recorded, and many of them offer good evidence that potential problems can be spotted and nipped in the bud. One woman was worried about possible damage to a new hedge she had just planted. Arrangements were made to build a temporary fence to protect it.

An expectant mother lived along the line, and complete plans were made so that she could have transportation to the hospital at any time of the day or night. Arrangements were made for garbage collection, mail and milk deliveries, and similar services. Every effort was exerted to see that business could proceed as usual.

These are but a few of the numerous instances which gave the company the opportunity to prove itself human. Residents were at first surprised and then pleased that they should receive such considerate treatment. They soon gained a sense of being a part of the job and adopted a helpful attitude to see that it was made easier.

It is true, as in most public relations activities, that the success of a program of this kind cannot be measured in cold dollars and cents. The company is convinced, however, that it was the most profitable investment that could have been made. The many unsolicited letters of commendation received and the thanks expressed by numerous customers for the consideration shown them are, of course, intangible results.

Rules for Success

One substantial benefit of the experience was the valuable information obtained on the problems of street relations. To get further information on these problems, they were discussed with the division managers, operating crews, and customers. Letters of commendation and criticism were reviewed to find out what people like or dislike about operations in the street. Out of all this was developed a pattern for good street relations. There seem to be four basic rules for success:

1. Let the people who will be affected know in advance when and why the utility will be working on or near their property.

2. Complete the job, or each section of the job, in as short a time as possible.

3. While on the job, make it as frictionless as possible.

4. Leave the completed job in good shape.

The method of implementing each of these four rules will vary, of course, depending upon the size and type of job. Here are a few examples of specific procedures which apply regardless of the size of the job.

1. *Notify people in advance.* On main replacement jobs, the company foreman or contractor foreman informs people along the block that a crew will be working that day or the day following and tells them the time any necessary shutdown is planned. In business areas, this contact should be made even

further in advance, if possible. On service replacement or alteration work, the crew leader discusses the job with the customer before any work is started, to work out a mutually agreement shutdown time. On any job where service will be interrupted, the customers are notified as soon as possible.

2. *Get the job done as rapidly as possible.* Jobs of any length are planned in short sections so that no group of people will be affected any longer than is absolutely necessary. Narrow trenches, mechanical trenching and backfilling equipment, and truck-mounted pavement breakers are used to speed up the job.

3. *Keep the job as frictionless as possible.* Driveways are backfilled or bridged each night so that residents can use their cars. Police and fire departments are notified in advance if any special traffic problems are likely to develop. Spoil piles are kept as small and as neat as possible. Equipment and pipe are stockpiled neatly. Special arrangements are made with owners of gas stations, restaurants, and markets to keep driveways and delivery alleys open. Crew members are warned against disregarding customers' property while eating lunch, using profane language, and the like. (In the eyes of the customer, the personal-contact phase of street relations is probably much more important than the physical aspects of the job. What should field men say when it is necessary to tell a customer that service will be off for several hours? How should they handle complaints—or compliments? What do they say when they are asked for service that another department handles? How do they take care of children and their countless questions about what is going on? A surly or indifferent crew leader will completely nullify the good features of a well-planned job. Conversely, a pleasant attitude will frequently smooth over a potentially disagreeable situation.)

4. *Leave the job in good condition.* Lawns, shrubs, and flowers are carefully restored. Sidewalks and streets are swept down. Loose papers and scrap materials are picked up. In general, it is necessary to practice good housekeeping.

These are just a few typical measures than can be taken to maintain good street relations. With the tremendous number of utility and contractor crews working in the streets every day, a great many people see and are affected by the work—more, perhaps, than in any other single phase of utility activities involving direct contacts with the public. The way these jobs are handled will have a tremendous influence on what people think of the utility. In the final analysis, public relations is the sum total of what people think of an organization.

By and large, the field men of public utilities are doing an excellent job. It is up to management to give recognition and encouragement to their public relations efforts, which will inspire them to do an even better job.

Indirect Contacts

Good public relations results from good performance—and getting credit for it. In order to get full credit for doing a good job, the utility must let people know about it. Many utilities today have an exceptional story to tell about miracles of engineering achievement and farsighted planning. But how many customers know this? How

many actually know where their gas fuel comes from; or their electricity; or their water? How many know, for example, that a ton of water delivered to a home in Los Angeles actually costs less than a nickel—literally cheaper than dirt? The customers have the right to know these things, and the utility has the right, along with the responsibility, to tell them.

The customers should also know something about the problems of providing good service, about how rates are determined, about financial needs in this era of tremendous expansion. A sympathetic public understanding of these problems is essential to the successful operation of any utility, whether publicly or privately operated.

Of course, the utility cannot tell a complete story in its daily contacts with customers and must, therefore, communicate indirectly with them through advertising and publicity in mass media.

Advertising, perhaps, offers a greater opportunity to reach and influence large numbers of people in a short time than any other means. Institutional and special-purpose advertising are particularly valuable tools of an effective, overall utility public relations program. Certainly advertising can be a tool of great force in educating and informing the public. It has the advantage of complete control over what is said and when it is said.

A public utility, even though it has a monopoly on its service, is justified in spending money for paid advertising. A utility has the responsibility of keeping the public fully informed about its operations. Customers also have the right to know about such things as rates, quality of service, and advantages of the product, and advertising is often the only means of imparting this information effectively and quickly.

Advertising alone will not, however, impart qualities to a business that are not in it. A business must make certain its house is in order before inviting people in for a look around.

A utility benefits in the form of improved public understanding of its business through buying advertising space. At the same time, it obtains improved press relations. This is not to imply that newspapers can be bought, but the editor certainly has a right to expect support from advertising revenue for his efforts in behalf of a community, and the public utility does well to do its part in keeping the local papers healthy and vigorous. The advertiser should not, however, assume that the purchase of advertising space gives him free access to the paper's news columns. There are altogether too many firms who try to take advantage of the poor, harassed editor in that way. Actually, there is a surprising amount of utility business that is legitimately newsworthy. The expansion of the system, quarterly and annual reports, growth, the doings of executives and other people—all this is the stuff that news is made of. And it all helps to tell the story to the public and improve its understanding.

While on the subject of press relations, a point should be stressed regarding adverse publicity. It was once nearly impossible for a newspaper reporter to secure any facts when utility accidents or other unfortunate events occurred that might make the headlines. As a result, utilities got a pretty bad name among the papers. Most utilities, however, have now seen the light and do their utmost to cooperate with the press in this respect. The

author's company makes every effort to supply newspapers with all the facts when an accident occurs and offers every facility to assist the reporter in getting the story. Experience shows that papers will generally be much kinder in their handling of stories when the utility is cooperative, and they will be much less likely to handle the story in a sensational way over a protracted period of time.

In addition to advertising and publicity, there are countless other ways to tell the utility's story if group contact opportunities are utilized. Here again employees must be relied on to interpret and pass on to the public the information it is desired to impart.

Participation in and support of community activities, such as fund-raising drives and civic-betterment programs, are excellent opportunities to demonstrate that the utility is a business run by people who are willing to assume the responsibilities of good citizenship.

There seems to be a greater need for public understanding of the public utility business today than ever before. All utilities, whether publicly or privately operated, are faced with the difficult job of explaining such complex matters as financing and the effects of inflation. This is the most serious problem of utility management today and the one which places the greatest strain upon public relations. Success in meeting this problem will depend upon the reservoirs of public support and acceptance that utilities have built up through the years by maintaining sound operating policies and good public relations.

Management of Small Watersheds

By David J. Guy

A paper presented on Oct. 31, 1952, at the Chesapeake Section Meeting, Washington, D.C., by David J. Guy, Exec. Vice-Pres., American Watershed Council, Inc., Washington, D.C.

IN the whole realm of natural resources conservation, there is no subdivision where the term management has a greater significance than in the field of water. Proper "water management" is basic to the highest, the optimum use of water resources.

Water resources management must begin with the small watersheds. It is here that the overall problem breaks down into its constituent parts. It is here that management, because of the interrelated interests of the people in the area, is afforded the greatest opportunity. The people in the watershed have the first proprietary right in the water. Their livelihood depends upon this water. And the abundance of their livelihood depends upon the way they husband their water resources. These, then, are the two pillars that support the American Watershed Council's arch: the small watershed and local management and control.

Fundamental to the problem is an understanding of the rather controversial subject of forest–stream flow and soil–stream flow relations. This field is not the domain of the forester and the soil technician alone. The geologist and the hydraulic engineer are equally indispensable because they are technically equipped to deal with the vast water-bearing formations that lie between the land surface and the so-called "basement rock" of the earth's crust. The trouble with the engineer is that he has failed to apply his hydrodynamic principles to water flow in the subsoil. He must know hydraulic gradients, slopes, transmissibility, cross-section area, and specific yield; and, by experimentation, he must establish the necessary working "coefficients," just as he has done with stream flow.

The engineer is inclined to the principle of control by force—*stop* with dams, *confine* in pipes and canals, *treat* with chemicals to purify. His approach is curative rather than preventive. The latter technique should not be overlooked, however. At least, the engineer should be willing to be shown. He should have an open mind toward experimental data. Water shortage in the soil is a fact. How much or how little, the engineer may question. But, as in his own profession, he must acknowledge that man can facilitate the control and storage of rainfall in the soil or bring about soil conditions that result in immediate runoff and rapid filling of stream channel storage capacity.

Need for Data

The science of hydrology as applied to the water in the soil is still relatively undeveloped. Land use as a factor in water management is a new subject

even to technicians in forestry and agriculture. Experimental data on which the engineer is accustomed to rely are lacking. Only recently have the engineers turned their attention in earnest to ground water conditions.

The type of experimental data needed may be illustrated by the work of the Coweeta Laboratory of the U.S. Forest Service in western North Carolina. There, a 5,600-acre watershed has been broken down into a number of small watersheds ranging from 25 to 200 acres. Water behavior in 28 of these subareas is now under intensive study. The soil is studied; topography, soil cover, weather, and storm conditions are observed and analyzed; and rain gages and runoff stations have been multiplied. Then, after a period of years, the aboveground conditions—forest cover, agricultural practices, and the like—are all changed, intentionally, and the whole record-taking program is repeated. Not only are data for the area being collected, but the whole pattern of experimentation is being developed. There has been little research of this nature in the past. The Emmon Valley study of the Forest Research Institute of Switzerland 50 years ago and the Wagon Wheel Gap, Colo., study undertaken by the U.S. Forest Service in 1909 are two of the very few examples.

Turning to soil conservation, the author is aware of no comparable, purely scientific research project, either of record or in progress on a watershed basis, in the field of agriculture. Although soil cover studies, as in the North Carolina project, may, after the removal of forest cover, include types of land use for agriculture, purely agricultural research projects, on a watershed basis, should also be established. This would afford a test of new ideas—chisel plowing, new fertilizers, chemical treatment—in relation to stream flow.

Reclamation, power, and navigation are specialized uses of water. They are associated with the problem of channelized water. The engineer in this field does not concern himself with watershed characteristics. Of course, he always wants to know the relation between rainfall and runoff, but he accepts this observed relationship just as he accepts the rainfall itself. Then he turns his whole attention to channelized flow and tries to reregulate it by force, to produce power, irrigate land, improve navigation, or reduce flood peaks.

What does the watershed mean to the water supplier? Obviously, the municipality or industry that gets its water supply out of the Ohio, Mississippi, or Columbia River is far removed from small watershed treatment, although, in the aggregate, the water supply is affected. But is is not necessary to go far from these rivers' banks to find ground water the main source of supply and watershed characteristics of immediate importance. Even if surface water from tributary streams is the source of supply, everything that happens in the watershed affects it. With knowledge of the meteorologic and topographic conditions, the forested areas, the soil cover, and the farming methods in a watershed, the water supplier can do more than just *observe* a rainfall-runoff relationship. He can develop ways and means of improving this relationship.

Forestation

One such method is the provision of forest cover, a field in which some water suppliers are doing outstanding work. The Newark, N.J., Water

Dept., which has a 40,000-acre watershed under a trained forester, has done a commendable job of tree planting. Rochester and Glens Falls, N.Y., have each planted more than 2,000,000 trees on their city forests. The York, Pa., Water Co. has planted several thousand acres, although the author understands that poor harvesting practices threaten the whole undertaking. Reading, Pa., has extensive planting on the city watershed.

The Providence, R.I., Water Supply Board owns 12,400 acres and has planted 6,800,000 trees in the past 25 years. The forester in charge has done an intensive forestry job, thinning young stands. A total of 2,200 tons of pulp wood and 200 cords of fuel wood have been sold, as well as witch-hazel and evergreen boughs. At Manchester, N.H., the municipal watershed forest covers 5,200 acres, harvested under sustained yield by resident foresters. Timber brings in $10,000 to $30,000 a year. The Washington, N.J., Water Co. had planted 28,000 trees up to 1946. It markets timber in accordance wtih the recommendations and practices of the New Jersey Dept. of Conservation.

Seattle, Wash., owns 62,700 acres in the Cedar River Watershed. Watershed management has been practiced since 1924. The allowable annual cut is 35 mil ft, with approximately 22.5 mil ft being cut yearly. The city has a contract with four private owners which provides for an orderly harvest, virgin timber to be removed over a 40-year period. Although logging has been heavy, the water commission reports that logging practices on the watershed in the past have had no discernible effect on precipitation, runoff, and quality of water. This is probably the outstanding municipal watershed forestry job in the United States.

In forest cover, a start has been made. But, according to C. G. Paulsen of the U.S. Geological Survey, the land-water problem is growing more pressing all the time. He states (*1*):

> The erosion of the land, the carrying away of the good topsoil, clogging of streams, reservoirs, and harbors, the cost of removing suspended sediment and rendering water suitable for public and industrial purposes are liabilities which should receive increased attention. This is all liability. The farmer loses his good topsoil. Public supplies and industries must spend money to remove the sediment, and rivers, harbors, and reservoirs are clogged. How much good topsoil do we have in the bank? How long will the one-way bank account last? What do we do when this one-way bank account is exhausted? What are we doing about it now? These are very pertinent and far-reaching questions.

American Watershed Council

Whether the problem is scarcity, superabundance, or contamination, the water supplier should look first to his own watershed. As the water works is a public utility, its operations, more than those of any other group involved, need the informed, sympathetic understanding, not only of their customers, but also of business and agriculture throughout their watershed. The American Watershed Council's main objective is to help organize these interests, not by counties or any other political subdivision; not for any one conservation objective, such as flood control, for example; not to fight some other group or interest; not just to get federal money; but for the purpose of mutual understanding, pooling of interests, compromising differences, and appraising the local community inter-

est as a whole—in a word, to gain perspective. And, of course, to learn the facts. No matter what government does, only the people can put soil and water conservation into effect. The well-being of any community depends upon citizen interest.

How do watershed groups get organized? In one locality, the people became angry about a "dam proposal" and held a mass meeting. More than 500 attended—merchants, farmers, and laborers. They needed money to get underway and an appeal was made. A big tin washtub was placed at each of two exits and, as the people dispersed, they made their contributions, until the tubs were nearly full. Other organizations, such as those at Miami and Muskingum, Ohio, proceeded more deliberately.

The council furnishes information on state laws, incorporation, by-laws, operation programs, consultants, and state and federal technical and financial assistance. It tries to knit together the raveled ends of community interest in natural resources, using the watershed community as a natural unit. Communitywide support is essential. The council's aim is for everyone in the community to be a part of the answer to the community's land and water problems and not part of the problem itself. Through membership in and support of a local watershed conservation organization, this transformation can be achieved. An eroded, deforested, fished-out, dried-up watershed area is unmistakable evidence of a chronically ill community.

There is no magic formula that will awaken all this interest overnight and reclaim a rundown watershed. But, if conservation can proceed all the way from the farm and the wood lot to the larger river basins, watershed by watershed, the nation's renewable resources problems will solve themselves, and the people will continue to prosper. All thoughtful men will subscribe to the creed of a Nigerian chieftain who said, "I conceive that the land belongs to a vast family, of which many are dead, few are living and countless numbers are still unborn."

Reference

1. PAULSEN, C. G. Water Balance Sheet for Ohio. *Proc. 1st Ohio Water Clinic* (1952).

Discussion

Edward S. Hopkins

Prin. Assoc. Engr., Bureau of Water Supply, Baltimore, Md.

To put the watershed management problem in proper perspective, it might be mentioned that Baltimore, Md., for example, requires a watershed of 467 sq miles for an impounding safe yield of 243 mgd from the Gunpowder and Patapsco rivers. This area will supply an estimated water-using population of approximately 1,244,000 in 1960. When it is recognized that the majority of water supplies in the United States serve small cities, it is apparent that their watersheds are extremely small in comparison to the vast areas considered in terms of river basin control.

The basic principles of soil management and land use can be advantageously practiced by everyone responsible for watershed operation and control. When the land is owned by the municipality or water company, soil management can be controlled directly by contour plowing, if cropping is per-

mitted, and by the planting of trees to reduce evaporation of moisture from the soil. When the land is not utility owned, a cooperative program should be established with county agents in the local territory who, in turn, would educate land users in soil management and water conservation.

Forestation

The author mentions various projects for tree planting on watersheds ranging in size from 5,200 to 62,700 acres. There are many watersheds where trees of various types have been planted to provide litter and humus that will absorb rainfall and form a protective covering over the soil, thus preventing erosion and subsequent silting of the impounded water. Baltimore, Md., in 1918 was among the pioneers in planting approximately 700 acres adjacent to the Loch Raven Reservoir with approximately 1,000,000 conifers. Upon completion of the Pretty Boy Reservoir in 1933, the adjacent area was also planted, and in 1950 additional supplementary plantings were put in.

Several programs have been established in cooperation with local soil conservation groups to control erosion. Farm agents have found that grazing land is also important in this respect.

The Washington Suburban Sanitary Commission has developed an extensive forestation program for Tridelphia Lake. Between 1943 and 1949 approximately 400,000 trees were planted as part of the program to conserve water and reduce silting in the lake. The commission owns 1,738 acres, of which 807 are in forest. After investigation and study in conjunction with the Maryland Soil Conservation Committee and the Maryland Forestry Dept., it was found that 235 acres could be planted for grazing or used for cropping. This land was leased to individuals and utilized under the direction of the county farm agents. The watershed area comprises 50,176 acres, and soil conservation districts have been established in the two counties in which the watershed lies, in cooperation with the Maryland Soil Conservation Committee. Financial assistance has been given by the sanitary commission to the conservation committee for preventive erosion work.

It must be confessed that the practice of forestation on watersheds has been given scant consideration by municipal and water company organizations. It is evident that, after the initial planting of trees on many watersheds, thinning would become possible and could be of economic benefit through the sale of logs or lumber. A profitable program of selective lumbering can be developed by the state forester and encouraged by the watershed control agency. Several cities, such as Manchester, N.H., North Adams, Mass., Newark, N.J., Reading, Pa., and Newport News, Va., employ foresters to manage their woodlands.

Watershed Sanitation

Water supply policy must also consider a sanitation program for watersheds. Hartford, Conn., North Adams and Fall River, Mass., Newark, N.J., and the North Jersey Dist. Water Supply Com. have purchased a large portion of their watershed areas to gain absolute control over the land. In such instances, regulations for sewage disposal from residences, picnicking, fishing, and swimming are directly enforced by the owner.

It is generally believed unnecessary to buy the entire watershed. The usual practice is to purchase a strip of

land at least 100 ft wide adjacent to a reservoir bank, but ownership of property abutting contributing streams is not economically practical. This land purchase, under the doctrine of riparian rights, gives the municipality or water company absolute jurisdiction over the shores of the reservoir. Under these conditions, sanitation of watersheds is a responsibility of the local health department, and rules and regulations for the disposal of sewage and other liquid and solid wastes are established by that agency. The enforcement of local health laws of benefit to the water purveyor may be obtained by cooperation with the local health department. Frequently officials of the water agency are designated as agents of the health department and directly enforce its rules and regulations.

Boston and New York are the two largest cities relying upon sedimentation in large reservoirs as the primary method for purification. The watershed area for New York covers 1,100 sq miles and for Boston, 500 sq miles. A comprehensive sanitation program for its watersheds has been instituted by New York. The water department maintains a sanitary patrol of watershed areas above the reservoirs. Inspectors cover regular routes through the area for the purpose of abating nuisances and discovering any health factor that should be brought to the attention of the local health department. They are employees of the city but function as representatives of the local health agency in the enforcement of regulations. New York also provided replacement sewage disposal facilities for the villages and institutions on the watersheds and thereby reduced contamination to a minimum.

A similar policy was followed by Baltimore in 1914, when it began to utilize water from the Loch Raven Reservoir. A scavenger service was inaugurated by the Baltimore Bureau of Water Supply for the cleaning of privies, septic tanks, and cesspools adjacent to the reservoir and larger streams feeding directly into it. This free service, which was continued for approximately 30 years, included rehabilitation and replacement of the privy houses, under certain conditions. With the development of modern purification control procedures at the filter plant, the sanitary hazard was no longer a problem of magnitude and this costly scavenger service was discontinued in 1946. It is of interest to note that, since the discontinuance of this service, there has been no undue nuisance complaint from overflowing privies, septic tanks, or cesspools. The decision to eliminate the scavenger service was taken after the basic sanitary policy had been changed to permit fishing in the reservoir.

It is believed that, with modern methods of purification, the recreational use of watersheds presents less potential hazard than domestic and industrial sewage pollution. In 1920 Newark, N.J., recognized that it was practically impossible to keep people from the reservoir and watershed areas and permitted recreational activity in three supervised localities. In 1944 the Washington Suburban Sanitary Commission permitted the use of watershed property for restricted recreational activities, including the establishment of two picnic areas and fishing from rowboats and on shore at various locations. Some of the boats are privately owned and others belong to the commission, but it is planned to eliminate the former. Hunting is not allowed, and two patrolmen are required for the watershed. Sanitary

conditions have been satisfactory. It is believed by the commission that the cost of providing these recreational facilities, which are not self-supporting, is justified to maintain the quality and safety of the water in the reservoir.

Fishing from boats was permitted in the Pretty Boy and Loch Raven reservoirs by the Baltimore Bureau of Water Supply in 1946, under a contract signed between the city and the League of Maryland Sportsmen. Motor boats are not allowed. Toilet facilities are located at the boat landing areas adjacent to these reservoirs. The league was designated the agent of the city in the operation of the fishing program and was required to provide adequate personnel to safeguard public safety and prevent pollution of the water. All boats are the property of the league. Fishing is not permitted from the reservoir banks or bridges. Sanitary regulations promulgated by the water supply bureau prohibit bathing, wading, swimming, and committing nuisances. Fishing has been practiced each summer and the sanitary regulations have been rigidly enforced. This recreational use of the reservoir has not increased the coliform organism index and must be considered a calculated sanitary hazard of minor importance.

The most outstanding use of reservoirs for recreational purposes is at Springfield, Ill., which permits boating, fishing, camping, and picnicking, with facilities provided by the water department. An urban housing development has been erected on the lake shore, with the inhabitants enjoying the usual bathing and other recreational activities on the watershed. A swimming pool of 240,000 sq ft has been constructed in the lake for public use. The overflow of chlorinated water from this pool returns to the lake. Complete purification is given to the public water supply prior to use.

Industrial Pollution Control

Watershed sanitation also includes programs for industrial-waste pollution control in cooperation with management. For example, Congoleum-Nairn, Inc., and the Schenley Distilling Co., both located at Cedarhurst, Md., have spent approximately $750,000 to eliminate their industrial wastes from the Patapsco River. This extensive treatment was instituted to remove industrial-waste hazards from the future water supply for the city of Baltimore. The waste treatment plants include lagooning, biofiltration, and chlorination of the effluent. Heavy color due to the rag wastes was satisfactorily reduced by the use of chlorine, and the river becomes normal, as judged by upstream characteristics, approximately 3 miles below the plant.

It is apparent that the problems of soil management and the elimination of domestic sewage and industrial pollution can be overcome through the cooperation of the county agent, the local health department, and the industries concerned.

Making a Water Utility Solvent

By E. D. Bonine

A paper presented on Apr. 18, 1952, at the Nebraska Section Meeting, Lincoln, Neb., by E. D. Bonine, Supt., Water Plant, Lyons, Neb.

A MUNICIPAL water system is a business and should be operated as such. It differs from the standard form of business in that it does not need to, nor should it, be operated at a profit. To be successful, it must, however, have ample income to meet expenses.

A successful business must have good management, good service, and a good product. With good management the rest should follow. As all municipal business must start with the village board or city council, the water department too frequently becomes tied up with the usual political strings. Board members may be good businessmen and yet, upon contact with municipal problems, may throw sound business practices out the window and be influenced by citizens who are interested only in something cheap.

In order to get the good management and efficient personnel necessary to a successful business, wages and salaries should at least equal those paid for similar jobs elsewhere in the community. Too often the municipal employee is at the bottom of the list.

Many people take water for granted, not realizing that it requires enormous amounts of equipment and labor to place water at their fingertips and keep it there. They compare their rates with rates in neighboring towns without knowing the conditions. Recently the author overheard one Lyons, Neb., resident telling another what a good rate a certain town in Nebraska had: no meters, just a flat charge of 75 cents per month for all water used. Now, that town has 350 water services. At 75 cents per month, the gross monthly water income is $262.50. As the power bill for pumping the water must be in the neighborhood of $90 per month, that leaves $152 for all other operating expenses and depreciation. This means the deficit has to be made up from taxes, which, in turn, means that the small water user is helping to pay the large user's bill.

Water is the cheapest of all commodities, whether figured by the gallon, pound, or ton. One dollar will buy 8 tons of it almost any place in Nebraska. When compared with other utilities, the telephone for instance, it is still cheap. In Lyons, a one-party telephone costs $3.65 per month and a minimum water bill is $1.25 per month; yet there will be twenty complaints about a water bill to one about the cost of a telephone.

Most authorities on water plant operation recommend that all operating expenses, repairs, and depreciation be paid out of revenues derived from the sale of water and charges made for tapping mains and running new services. As adequate fire protection calls for a larger water supply, more pumping capacity, and larger mains and hydrants, and as it is definitely a benefit to the entire community, these authorities recommend that a charge, usually

in the form of a hydrant rental, be made against the city and be paid for from taxes levied for that purpose.

In 1951 the Fremont, Neb., Dept. of Utilities made a survey of 27 cities in Nebraska. It was found that there was a considerable variation in rates and in investment per customer, probably depending on the availability of the water supply, the type of water, and the process it must go through before being delivered to the user. Practices with regard to meter ownership and service installation also varied a great deal. Another important item that followed no definite pattern was the hydrant rental charge. Most of the cities surveyed had a low operating ratio, with a few showing quite a margin of profit and others a loss.

To go from the general to the specific, the author would like to describe the problems encountered in operating the Lyons water system since 1950, when he became superintendent. Lyons has had a lime softening plant since 1939, although by 1950 it had deteriorated almost to the nonoperating point. The plant was, however, still feeding seven sacks of lime a day, most of which was passing through the filters and into the mains. The water plant adjoins the light plant and is operated in conjunction with it. Even with only one man's time being charged to the water plant and with free power, the water department was losing money. Out of 400 customers on the system, only 210 had meters that were registering. This fact, together with the water rates in effect, added up to an average income of $1.00 per month per customer, or $400 per month total income for the water department. After having had soft water for a few years the customers were very unhappy with the water they were getting, although it was cheap.

By using what records were available and estimating the rest, a valuation for the entire system was set at $72,763. During the first year the department drilled one new well, laid 1,600 ft of new mains, rebuilt the softening equipment, and added one high-service pump. These items raised the total valuation to $86,761. Depreciating this valuation completely over a 50-year period, the monthly depreciation cost came to $171. After keeping close check on the operating expenses for 6 months, the average monthly operating cost was calculated to be $638, which, plus the depreciation cost of $171, totaled $809.

With most of the customers on meters and an actual cost to aim at, various rates could be applied to the customers meter readings, in order to find a schedule which would furnish an income equal to expenses. The rate schedule finally adopted was:

Quantity *gal*	Price per 1,000 gal $
First 5,000	0.75
Next 5,000	0.45
Next 10,000	0.35
Next 30,000	0.25
Excess	0.15

The quarterly minimum bill was $3.75.

This rate slightly more than doubled all water bills, with the exception of the larger users, whose bills were increased only a maximum of $5.00 per quarter. The majority of the people were happy to have soft water again, and very few have complained.

At this writing, the new rates have been in effect one full quarter, bringing in a monthly income of $818. With this income, plus eighteen more customers yet to be metered and a hydrant charge to be added, it is believed that the water department is well on its way to recovery.

Evaluating Water Supply Requirements for a Region

By John R. Stockton

A paper presented on Oct. 13, 1952, at the Southwest Section Meeting, Tulsa, Okla., by John R. Stockton, Director, Bureau of Business Research, Univ. of Texas, Austin, Tex.

THIS paper will describe the methods used by the Bureau of Business Research of the University of Texas, Austin, Tex., in estimating future water requirements for a relatively small area. As the provision of an adequate supply of water usually necessitates a large capital investment, a forecast of water requirements is absolutely essential. The fact that it is obviously impossible to make an accurate forecast for 50 years does not remove the need for it. A decision to build a dam and lay pipelines, for example, implies a forecast. Insisting that forecasting is impossible and then making a decision that is in itself a forecast has disadvantages over boldly stating the forecast that underlies the decision.

The business research bureau has prepared three studies that included estimates of potential water requirements for a region in Texas and is currently engaged in preparing a fourth. All these studies have been made for the U.S. Bureau of Reclamation for use in its planning. The business research bureau's methods of estimating potential water requirements can be illustrated by the results of its study of the Amarillo trading area, published in 1952 (*1*). The Amarillo study shows all of the major techniques used, although some refinements have since been made.

The demand for water in an area may be expected to rise with increased population and industrialization. Water consumption figures for different cities show wide fluctuations even when reduced to a per capita basis, as the use of water by industries in different areas varies widely. Obviously some industries use more water than others, so that, unless industrial use is separated from domestic use, comparisons and forecasts will be rather meaningless. It has been found advisable, therefore, to estimate potential domestic and industrial water consumption separately. The bases for a forecast of domestic water consumption are, first, a forecast of population, and second, a forecast of per capita water consumption. The forecast of industrial water consumption requires a projection of the trend of the industries in the area; the consumption of water by an industry may be expected to increase with the output of that industry, except for changes that may occur in water consumption per unit of product.

Population and Economics

The forecasting of the population for an area is sometimes done by projecting births and deaths, but with the

great mobility of population in the United States, the shifting of people from one area to another as better jobs present themselves makes it more important to consider economic rather than biological factors in forecasting the growth or decline of population. In the author's opinion, the forecasting of population for small areas is almost entirely a problem in economics rather than a problem in biology. No matter what the excess of births over deaths, the population of an area will not increase if economic opportunity does not exist. The people will simply move to some area that does offer economic opportunity, with the result that one area declines in population while another gains. The shift of population from the rural areas to the cities in the Southwest has been so great as to be obvious to everyone.

The business research bureau has been working on the assumption that the most important matter to consider in forecasting the population of an area is the determination of the possibilities for growth in the economic base that supports the population. This economic base consists of industries that use local resources to produce goods or services which can be sold outside the area and thereby create income that can be used to buy goods and services from outside the area. Industries producing goods and services that are consumed only within the area do not create economic activity to the same degree as industries producing for wide distribution. Someone once remarked that a community could not prosper if the only economic activity consisted of taking in each other's laundry.

Industries that are based on local resources and produce goods and services for export from the area are "basic industries," while those industries that produce goods and services to be consumed locally are "service industries." Agriculture, oil and gas production, through transportation, and tourist attractions are examples of basic industries (location and recreational facilities are local resources). Bakeries, educational institutions, local transportation, wholesale and retail trade, and repair shops are examples of service industries. Frequently the two types of industries are represented in the same business concern, with the result that it is virtually impossible to separate them accurately. By a careful study of the economy of an area, however, it is possible to make a reasonably satisfactory allocation of employment between the two groups. When this division is made, the income provided by employment in the basic industries is considered to "support" the employment in the service industries. If a new plant in a community uses local resources and employs 500 workers who produce goods for sale in other sections of the country, the income of these employees will create a demand for additional goods and services in the community. The additional workers required to take care of this new demand may be thought of as being supported by this new basic industry.

Steps in Analysis

The first step in the analysis is to study the 1940 and 1950 employment data for each trading area, using the census of population for the purpose of determining how many employees in each industry group are basic in the sense described in the previous paragraph. When the total employment in

all of these basic industries is obtained, the difference between that total and the total of all employed persons is the number of service workers.

The second step is to compute the number of service employees supported by the basic employees in each industry. It is not logical to divide the service employees proportionately among the basic industries. Earnings vary widely in different industries, and the number of service workers that can be supported by a given number of basic workers depends upon the earnings of the latter. Table 1 shows how this calculation is made, using data for the Amarillo trading area to illustrate the method. The basic employment for 1940 was computed to be 31,841 and the service employment supported by it, 44,412. (When this study was made, employment data were available for 1940 but not for 1950.) Agricultural workers were given a weight of 1.0, and all other industries were expressed as a ratio to agricultural workers, based on the wage scales prevailing in each industry. For example, workers in the oil and gas industry received earnings 1.7 times those in agriculture. Each industry was given an income weighting factor, which was then multiplied by the number of basic employees in the industry. These weighted employment factors were then used to distribute the service employment, already determined to be 44,412. Using the number of basic

TABLE 1

Ratio of Employment in Service and Basic Industries, Amarillo Trading Area, 1940

Basic Industry	Workers in Basic Industries	Income Weighting Factor*	Weighted Employment	Workers in Service Industries†	Ratio of Service to Basic Workers‡
Agriculture-based					
Farms	20,069	1.0	20,069	21,915	1.09
Food processing	1,061	1.3	1,379	1,506	1.36
Mineral-based					
Oil and gas production	4,380				
Refining	2,262				
Total	6,642	1.7	11,291	12,329	1.86
Other minerals	61	1.0	61	67	1.09
Chemicals	1,285	1.7	2,185	2,386	1.86
Stone, clay, and glass	83	1.0	83	91	1.09
Metal fabrication	469	1.5	704	769	1.64
Nonferrous metals	651	1.5	977	1,067	1.64
Total	9,191		15,301	16,710	
Through rail transport	1,320	1.5	1,980	2,162	1.64
Tourist traffic§			1,682	1,836	
Trucking	200	1.3	260	284	1.42
Total or avg	31,841	1.24	40,671	44,412	1.395

* Taken from index of wage scales in basic industries.
† Allocated in same proportion as weighted employment.
‡ Number of service workers supported by one worker in a basic industry—secured by dividing service employment by basic employment.
§ No census count given; relative importance of this industry was estimated.

employees in each industry and the number of service employees for the same industries, it was possible to compute the ratio of service employees to basic. For example, each 100 persons employed in agriculture supported 109 service workers in the Amarillo trading area in 1940. Each 100 employees in the oil and gas industry supported 186 service workers. This ratio was computed for each basic industry in the area and was ready for use in projecting employment.

By this method it is not necessary to project the service employment dependent on the basic industries, since the number of service workers can be computed from the ratio of service to basic employment. One exception is the tourist trade. It supports service employment but has no basic employment, so the service employment must be projected as if it were a basic industry. The projection of the employment in the basic industries represents the most important element in the whole forecast of water requirements, because it will determine the size of the future population, and the industrial growth that causes the change in employment will also determine the future water requirements.

The forecast of the growth of individual industries in an area is obviously fraught with many hazards, but, just as obviously, it must be done if the estimate of future population and water requirements is to be anything more than a guess. The growth of individual industries can be projected by taking an inventory of the resources existing in the area and making an evaluation of their potential future use. Whether or not they will be used will depend chiefly upon demand in the national market, as these industries sell outside the local area. Using all available forecasts of the growth of the United States population, the rise in its standard of living, and the growth in foreign trade, the potential of each industry, based on a logical share of the national market, is determined. It should be emphasized that these estimates are in the nature of a statement of the amount of growth that can be realized in an area if a strong effort is made to develop the existing resources to their maximum potential. This is not exactly the same as a forecast, the word "forecast" being used in this discussion to imply such an estimate of potential. A large amount of material accumulated in many places during the past few years gives some indication of the potential growth of many important industries. The best recent example is the report of the President's Materials Policy Commission (*2*). None of this material should be overlooked, just as none of the resources available in an area should be neglected. The more completely the basic data are studied, the more soundly based will be the industry forecasts.

After a future production trend for each industry has been established, the forecast for employment in these industries offers no particular hazards. The forecast of employment will not always be the same as the forecast for production in an industry, however, owing to changes in productivity, but such changes usually take place rather slowly.

When employment in the basic industries has been projected as far into the future as the forecast is to be made, service employment may be computed by using the ratios of service to basic derived in Table 1. In the Red River study, on which the research bureau is currently working, it is trying to determine whether or not there is any

upward or downward trend in this ratio; in previous studies it was assumed that the trend was horizontal, so that the same ratio could be used for all forecasts. Table 2 shows the basic employment by industries for the Amarillo trading area, the supported 1940 was 227,663, or 262 persons for each 100 in the labor force. By estimating the amount of unemployment in the future, a figure for the labor force was derived, which, by the use of a ratio of population to labor force, gave the projected total population.

TABLE 2

Estimated Employment and Population, Amarillo Trading Area

Classification	Employment and Population in Year Shown							
	1940*	1950	1960	1970	1980	1990	2000	2010
Basic employment								
Agriculture								
Farms	20,069	21,593	22,300	22,150	21,550	21,000	20,450	19,900
Food processing	1,061	1,407	1,700	1,850	1,950	2,000	2,050	2,100
Oil production	3,230	3,720	3,930	4,980	7,410	11,240	13,676	14,268
Gas production	900	1,400	1,850	2,240	2,570	2,820	2,990	3,120
Petroleum refining	2,262	3,200	3,440	4,070	4,750	5,540	6,330	7,120
Natural gas transmission	250	520	700	840	950	1,040	1,100	1,140
Chemicals	1,285	3,540	5,200	5,695	6,860	6,825	7,285	7,785
Metal fabrication	469	900	980	1,170	1,500	2,000	2,340	2,420
Nonferrous metals	651	1,040	1,200	1,200	1,200	1,200	1,200	1,200
Through transport	1,520	2,330	3,160	3,780	4,410	4,910	5,330	5,640
Government	0	3,500†	4,000	4,000	4,000	4,000	4,000	4,000
Other	144	300	400	480	540	590	630	660
Total basic	31,841	43,450	48,860	52,455	57,690	63,165	67,381	69,353
Service employment								
Agriculture								
Farms	23,073	23,540	24,310	24,140	23,490	22,890	22,290	21,690
Food processing	‡	1,910	2,310	2,520	2,655	2,720	2,790	2,855
Oil production	12,329	6,900	7,310	9,268	13,780	20,910	25,440	26,540
Gas production	‡	2,600	3,440	4,170	4,780	5,245	5,560	5,800
Petroleum refining	‡	5,950	6,400	7,570	8,835	10,300	11,770	13,240
Natural gas transmission	‡	970	1,300	1,560	1,770	1,930	2,050	2,120
Chemicals	2,386	6,580	9,670	10,590	12,750	12,700	13,555	14,475
Metal fabrication	769	1,480	1,610	1,920	2,460	3,280	3,840	3,970
Nonferrous metals	1,067	1,710	1,970	1,970	1,970	1,970	1,970	1,970
Through transport	2,446	3,820	5,180	6,200	7,230	8,050	8,740	9,250
Government	0	4,500†	6,000	6,000	6,000	6,000	6,000	6,000
Tourist	2,184	3,200	4,100	4,900	5,400	5,800	6,100	6,200
Other	158	330	440	520	590	640	690	720
Total service	44,412	63,519	74,040	81,320	91,710	102,435	110,795	114,830
Total employment	76,253	106,969	122,900	133,775	149,400	165,600	178,176	184,183
Unemployment	10,525	4,272	7,845	8,539	9,536	10,570	11,373	11,756
Total labor force	86,778	111,241	130,745	142,314	158,936	176,170	189,549	195,939
Population								
Population (except student and military)	227,663	279,387	341,244	371,440	414,823	459,804	494,723	511,401
Student and military	0	0	12,000	12,000	12,000	12,000	12,000	12,000
Total adjusted population	227,663	279,387	353,244	383,440	426,823	471,804	506,723	523,401

* Actual census figures.
† Special adjustment to cover interim construction activities.
‡ Included in above.

service employment, and the other calculations needed to carry the forecast from total employment to population. The 1940 census gave the employment as 76,253, and the total unemployment as 10,525, with a resulting labor force of 86,778. The total population for The figure for student and military population shown for 1960 and later years was based on the expectation that an expanded military program would be continued. Worksheets are set up to include college students with military personnel in cities with large

college enrollments. Only colleges that bring in students from outside the city would be considered under this heading, so no students were entered on this line in the Amarillo study.

Estimate of Water Needs

With a projection of the population and another of the growth of the industries in the area, it is possible to bring together an estimate of the potential water needs. As a base from which to project water demand, a survey was made of the total water consumption in the Amarillo area. Every large industrial water user was interviewed to learn the amount of water consumed in 1950 and the source from which it was secured. The total amount of water delivered by public water systems was also found. In some communities, a canvass of the nonindustrial consumers supplied by private wells would be required in order to obtain a complete total of such water use, because the public system rarely supplies all the industrial or nonindustrial water consumers. From the survey among large industrial water users, the total amount of water consumed by concerns that represented basic industries (according to the definition used in this study) was determined. By subtracting from total water deliveries the purchases of water from the city system by basic industries, the amount of water consumed by households and service industries was determined for 1950. This was termed "nonindustrial water consumption" and was assumed to increase with the population, or somewhat faster than the population, to take care of a gradually increasing consumption per household for domestic, municipal, and commercial purposes. This increased consumption per household may be explained by a generally increasing standard of living, which is reflected in such items as more lawn sprinkling, air conditioning, and domestic water-using appliances.

The consumption of water by basic industries ("industrial" water) was projected at the same rate as the growth expected in each industry, unless there was direct evidence that some change would occur in the amount of water that would be needed per unit of product. The total of nonindustrial and industrial water demand gives the total water requirements for the area.

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Chlorination of Variable Flows

By John B. Hazen

A contribution to the Journal by John B. Hazen, Supt., Butte Water Co., Butte, Mont.

THE Butte, Mont., Water Co. Basin Creek supply consists of a 60-mil gal reservoir on Basin Creek and a 360-mil gal reservoir located at the junction of Basin Creek and Bear Gulch, which collect water by gravity from the surrounding mountains, augmented by water pumped from the Big Hole River over the Continental Divide. Approximately half of Butte's distribution system is supplied directly by gravity from the 360-mil gal Basin Creek Reservoir. The flow from this reservoir is extremely variable and unpredictable, ranging from a reversal of flow into the reservoir to a maximum rate of 16 mgd out of the reservoir. The flow from the reservoir is metered by a 30 × 13-in. venturi tube with a Type M register-indicator-recorder.* This meter records the entire range of flow with accuracy sufficient for controlling chlorination. Ordinarily a venturi meter does not record accurately over such a wide range, but for some reason this one does.

Manually controlled chlorination of this variable flow was not entirely satisfactory. After the end of World War II serious consideration was given to developing a means of controlling the chlorination of this supply automatically. As the variable-flow chlorinating machines on the market did not have sufficient range to meet the conditions at Butte, it was necessary to adapt equipment which was being manufactured for other purposes. The method selected was one by which a 100-ppm chlorine solution could be pumped into the mains using an electronically controlled d-c motor-driven pump which would speed up and slow down with the change in flow.

The control equipment includes a telemeter transmitter* (attached to the Type M recorder) consisting of a trip arm connected to the main lever of the recorder and a revolving cam which completes one revolution each 15 sec. The trip arm is positioned on the revolving cam by the main operating lever of the venturi meter recorder, so that, when no flow is being recorded, the trip arm remains completely off the cam. As the flow increases, the trip arm moves onto the cam, riding the cam for a part of the 15-sec cycle in proportion to the rate of flow of the water through the venturi tube. When the trip arm rides the cam, a mercury switch † is closed, completing the electric circuit between the transmitter and a telemeter receiver.* When the trip arm of the transmitter is off the cam, the switch

* A product of Builders Iron Foundry, Providence, R.I.

† Made by Mercoid Corp., Chicago.

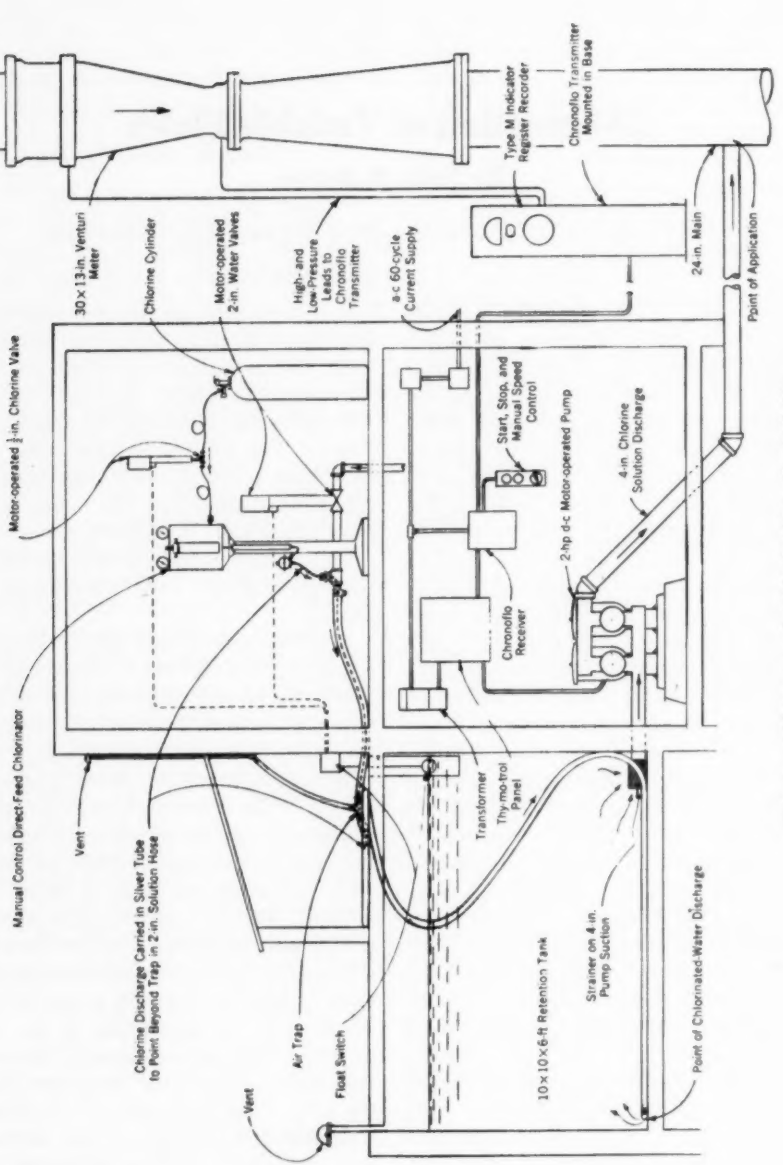

Fig. 1. Diagram of Chlorinating Installation

is held open by a magnet, breaking the circuit to the receiver.

The telemeter receiver consists of a telephone type relay, a reversing magnetic clutch driven by a small synchronous motor, and a potentiometer. The clutch mechanisms adjust the position of the potentiometer so that it can vary the speed of the electronically controlled d-c motor. When the electric circuit from the transmitter to the receiver is closed, the relay engages the increase clutch until the circuit from the transmitter is broken. Then it engages the decrease clutch until the circuit is closed again. In this way, the two clutches position the potentiometer, with the increase clutch moving up from zero position to the potentiometer operating lever. If there has been no change in the rate of flow it will be knocked out at this point, and the decrease clutch will move up from its zero position and be knocked out when the transmitter circuit is again energized. If there is an increase in flow, the transmitter circuit will stay closed for a longer portion of the 15-sec cycle and the increase clutch will remain engaged long enough to move the operating lever of the potentiometer to an advanced positon. In the same way, if the rate of flow decreases, the decrease clutch remains in operation for a longer portion of the 15-sec cycle and moves the potentiometer lever so as to decrease the motor speed.

The electronic control panel * enables the d-c motor to be controlled from an a-c supply. An uncontrolled electronic rectifier supplies power to the motor field. A second, grid-controlled, rectifier supplies variable-voltage direct current to the motor armature to obtain adjustable speed, up to the full speed rating of the motor. In addition to starting, stopping, and speed control, the panel provides overload protection, current limit control, voltage drop compensation, and dynamic braking.

In this manner, the transmitter, positioned by the venturi meter recorder, sends a time impulse to the receiver, which uses this time impulse, through its relay and positioning clutches, to position its potentiometer to control the speed of the d-c pump motor, with the electronic unit providing power rectification and controls.

The chlorine is fed by manually controlled direct-feed equipment.† The open end of the silver chlorine discharge tube is inserted into a 2-in. rubber water hose, where it mixes with a flow of water so regulated that the chlorine will all be in solution when it comes from the 50-ft length of hose. The rate of flow of water in the hose must be sufficient to carry the chlorine gas along, but, if it is too rapid, the chlorine will not go into solution. The first 20 ft of hose lies flat and level, as it is in this portion that the chlorine goes into solution. Then the rest of the hose passes through the roof of the solution tank to the tank floor.

The level in the $10 \times 10 \times 6$-ft covered reinforced concrete solution tank is controlled by a float-operated mercury switch which energizes a normally closed 2-in. power-operated valve on the water supply and a $\frac{1}{2}$-in. valve on the chlorinating machine. When the float drops, the switch closes, opening the valves so that water and chlorine flow into the hose. When the tank fills, the mercury switch opens, shutting off

* Equipment made by General Electric Co., Schenectady, N.Y., is used.

† Made by Wallace and Tiernan Co., Inc., Newark, N.J.

the chlorine and water. The 2-in. rubber solution hose is curved up and vented, forming a trap between the 2-in. valve and the point where the chlorine is discharged into the hose from the silver tube. This prevents the chlorine from backing up and damaging the valve and other equipment. The $\frac{1}{2}$-in. valve is equipped with a neoprene diaphragm having a $\frac{1}{32}$-in. plastic * liner, with a lubricant between them to permit slipping. The diaphragm arrangement has worked very well for controlling the dry chlorine gas.

The greatest difficulty experienced was in getting satisfactory pipe and fittings for the pump discharge line to carry the solution from the pump to the transmission mains. Plastic pipe seems to be working very well. Fittings were cut from the pipe in a miter box and welded or fused with a very small blowtorch.

* "Teflon," made by E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

The plant has been in service for more than 2 years and is doing a very good job. There has been a sufficient saving in chlorine over former manual-control methods to justify the cost. The bacteriological results have been excellent, and chlorinous tastes have been completely eliminated in this supply. A wide range of control is available. The motor control unit has a 20:1 speed control ratio, and it is possible to vary the length of stroke on the feeder pump, as well as the strength of the chlorine solution.

The new plant requires much less of the operator's time. Operating costs have been limited to electric power for the 2-hp motor, heat for the building, and a few tube replacements. The total plant cost, including building, equipment, planning, and installation, was $10,500. Not included in this figure are the chlorinating machine and the venturi tube and recorder, which were already in use.

ASA Approval of Gas Pipe Specifications

Three specifications for cast-iron pipe for gas received final American Standards Assn. approval on Mar. 30, 1953:

A21.3—American Standard Specifications for Cast Iron Pit Cast Pipe, for Gas

A21.7—American Standard Specifications for Cast Iron Pipe Centrifugally Cast in Metal Molds, for Gas

A21.9—American Standard Specifications for Cast Iron Pipe Centrifugally Cast in Sand-lined Molds, for Gas

These specifications are published by the American Gas Assn., 420 Lexington Ave., New York 17, N.Y.

Materials for Chemical Handling Equipment

By L. R. Honnaker and M. L. Monack

A paper presented on Nov. 6, 1952, at the Virginia Section Meeting, Old Point Comfort, Va., by L. R. Honnaker, Group Supervisor, and M. L. Monack, both of E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.

THIS paper is limited to a discussion of construction materials suitable for use with water treatment chemicals at the point of their addition. It does not include consideration of material requirements at locations elsewhere in the system. The chemicals discussed include alum, iron sulfate, activated silica, alkalis, chlorine, and fluorides.

A schematic representation of the equipment generally used for dissolving and handling some of these chemicals is shown in Fig. 1 and 2. The equipment involved in these installations consists mainly of tanks and piping. A listing of materials that are regularly used or are satisfactory for handling the chemical solutions in the strengths commonly involved is given in Table 1.

This list does not contain any new alloys or metals, primarily because no new alloys that have been developed or introduced commercially are economically attractive for use in this service. Some new high-alloy stainless materials have been developed, but they are of very little interest in this discussion. Titanium is one of the metals most recently introduced on a commercial basis, but, because of its current high cost, its use cannot be justified in the handling of these chemicals.

Rubber Lining

The excellent resistance of rubber to the chemicals used in water treatment, together with its adaptability and ease of installation and repair, makes it excellent material for lining tanks, piping, and other items of equipment. The soft rubbers that are generally used are adequate for the solutions and temperatures involved. The semihard and hard rubber compounds will generally provide somewhat better chemical resistance, particularly when the temperature is more than 150°F. Actually, however, all grades of natural and synthetic rubber lining compounds are suitable for use at temperatures up to at least 150°F, and generally up to 170°F, so that there are no temperature restrictions on the use of rubber compounds in water treatment equipment. It should be mentioned that care is necessary in handling hot, high-purity water, as it permeates rubber and causes blistering.

Rubber compounds of each of the various grades that can be applied to equipment in the plant are now available. Size of equipment or shipping conditions need not restrict the use of rubber linings. The development and extended use of the spark test to detect pinholes and discontinuities in

seams and joints has done much to improve the serviceability of rubber-lined equipment. It is good practice for the plant to spark-test rubber-lined equipment when it is received from the applicator, because shipping subjects it to some abuse which might

izing, heat or a combination of heat and pressure being used. The lining process is sufficiently flexible to permit rubber to be used for lining almost any shape of vessel or other equipment. As a matter of general practice, equipment that can be handled by rail or

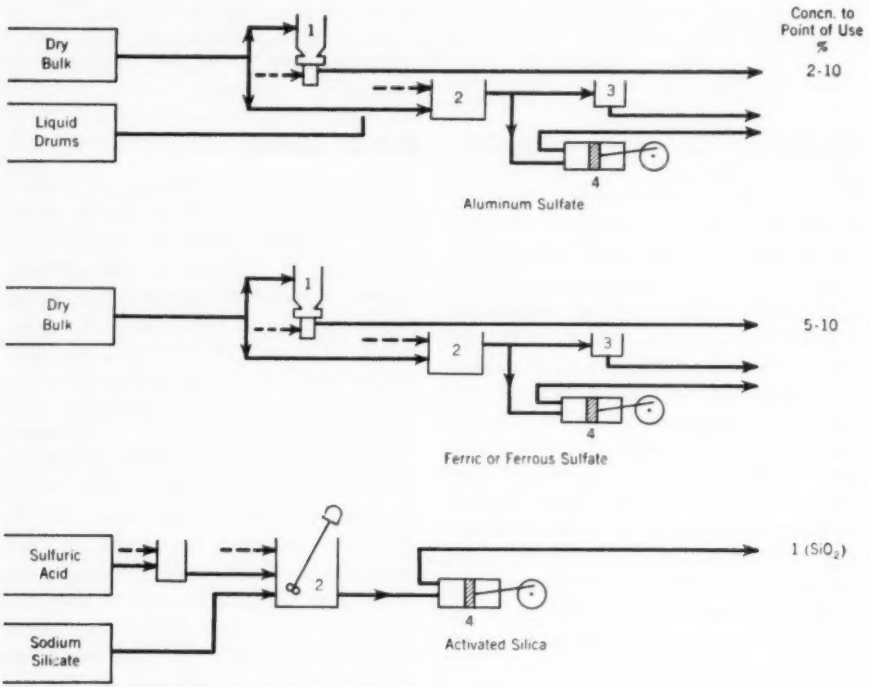

Fig. 1. Schematic Diagram of Equipment for Handling Coagulants

Key: 1—dry chemical feeder, volumetric or gravimetric; 2—dilution tank; 3—orifice type feeder; 4—volumetric pump.

open a seam or otherwise cause a leak. At one plant, rejects have run as high as 10 per cent.

Rubber lining of equipment is accomplished through the use of calendered sheet stock and adhesives. The optimum properties of the material are then brought out by curing or vulcan-

truck is lined in fabricators' shops, where the rubber can be applied under controlled conditions. There are compounds available in all grades, however, that can be cured in hot water or exhaust steam. It is practical, therefore, to line tanks and other equipment in any plant or location

where steam or a means of heating water close to the boiling point is available.

Rubber-lined pipe and fittings are widely used in the chemical industry to handle corrosive solutions. They are known to be quite satisfactory for handling all the solutions involved in water treatment. Flanged pipe and fittings are almost always used where rubber-lined piping is involved. Rubber compounds can be installed in standard flanged piping in sizes larger than $1\frac{1}{2}$ in. This is regularly done in pipe sections up to 20 ft in length. The lining thickness is generally $\frac{1}{8}$ in. in small-diameter pipe and $\frac{3}{16}$ in. in the larger sizes.

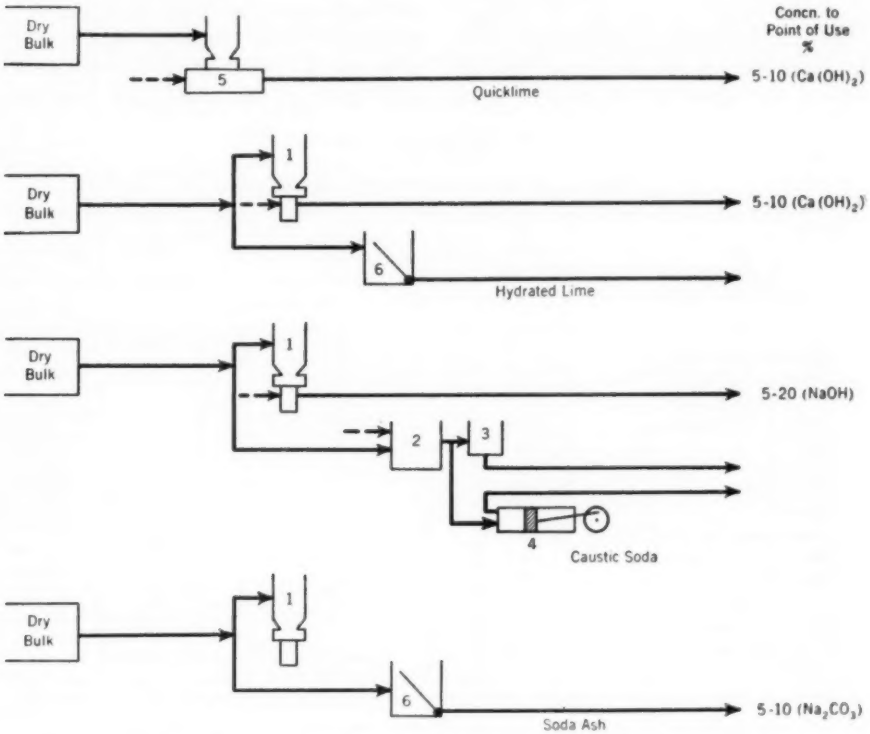

Fig. 2. Schematic Diagram of Equipment for Handling Alkalis

Key: 1—dry chemical feeder, volumetric or gravimetric; 2—dilution tank; 3—orifice type feeder; 4—volumetric pump; 5—continuous lime feeder and slaker; 6—wet chemical mixer and feeder.

Rubber-lined piping should be installed with reasonable care. The bolts should be tightened gradually, in rotation, to avoid excessive localized stresses, and the bolt pressure should not exceed that required to maintain

a tight joint at operating pressure. A number of vendors can now supply rubber-lined fittings and pipe of standard length from stock. Where special lengths are required, shipment can generally be obtained in approximately two weeks.

A drawback to the use of rubber-lined piping, particularly where time is important, is the necessity for detailing the layout to the exact lengths of pipe required. In this connection, it is of interest to mention a special type of joint that makes it practical to cut standard lengths of rubber-lined pipe to required size in the field and make flanged joints. A cross-section of this joint is shown in Fig. 3. It is possible to use adapter flanges and gaskets to permit this type of flanged end to be joined to a standard flanged end. The vendor currently carries the pipe and fittings in stock and will cut pipe to desired length and prepare ends prior to shipment, if desired.

TABLE 1

Materials With Suitable Chemical Resistance

Material	Alum	Iron Sulfate	Activated Silica	Alkalis	Chlorine Water	Fluorides
	S = Suitable					
Steel or cast iron			S	S		
Brass and bronze	S		S			
Type 316 stainless	S	S	S	S		
Type FA20 stainless	S	S	S	S		
Lead	S	S	S			
Rubber	S	S	S	S	S	S
Polythene	S	S	S	S		S
Uscolite	S	S	S	S	S	S
Polyvinyl chloride	S	S	S	S	S	S
Vinylidene chloride	S	S	S	S	S	S
Phenolic resins	S	S	S		S	S
Furan resins	S	S	S	S	S	S
Glass and glass lined	S	S			S	
Porcelain and stoneware	S	S			S	
Wood	S	S	S			

Liquid Neoprene

A high-solids-content liquid neoprene material can be used to line or coat equipment by brush or spray application. This material can be applied as a liquid to a thickness of 0.01–0.02 in. per coat. By multiple applications, reasonably thick, impervious, chemically resistant linings can be formed. A putty is also available for trowel application. Heatless curing takes place through the action of a chemical accelerator which is added prior to application. Drying time between coats is approximately an hour and the completed coating can be used approximately 48 hours after application of the last coat. When the coating can be heated to 180°F, curing

can be completed in approximately 2 hours.

The liquid neoprene compounds have proved quite useful and satisfactory for lining or coating miscellaneous fittings and other items of relatively small size. They can generally be considered as a substitute for rubber linings in handling water treatment chemical solutions. It is not intended to imply that the liquid neoprene is as good as a sheet-rubber lining, but its availability does make it possible to avoid delays incidental to the procurement of standard or custom-built equipment. The neoprene materials can also be used to repair damaged natural-rubber linings.

Liquid neoprene can also be used as a sealer for wood stave tanks. If properly fabricated, such a tank is very satisfactory. It is necessary to allow for the thickness of the neoprene sealer.

Plastic Piping

Plastic piping is being more and more widely used as a replacement or alternative for metal piping, especially when low pressure and moderate temperature are involved. Where plastic piping and tubing have been used within their limitations and where due consideration has been given to proper installation and support, they have provided good service. Several plastic

TABLE 2

Cost of Piping Materials

Material	Cost				Standard Pipe Length *ft*
	1-in. Pipe $/*ft*	2-in. Pipe $/*ft*	1-in. 90-deg Ell $	1-in. Tee $	
Carbon steel	0.15	0.35	0.79	1.19	20
Cast iron		0.56			5
Polythene	0.21	0.48	1.22	2.02	200
Saran*	0.60	1.20	1.01	1.26	10
Hard rubber	0.77	1.65	2.00	2.60	10
Uscolite†	0.88	2.08	1.50	1.74	10
Boltaron 6200‡	0.83	1.60	2.96	3.82	10
Lead ($\frac{1}{4}$-in. wall thickness)	1.00	1.80			20
Red brass (85–15)	1.04	2.33	0.61	0.87	12
Lead-lined steel ($\frac{3}{16}$-in. expanded, flanged)	1.50	2.70	8.50	10.42	20
Saran-lined steel	1.54	2.64	14.19	19.80	10
Haveg 41 (flanged)§	1.97	3.07	8.06	10.45	10
Rubber-lined steel ($\frac{1}{4}$-in. thick, flanged)	2.30	2.86	13.20	20.18	20
Lead-lined steel ($\frac{3}{16}$-in. homogeneous, flanged)	2.25	3.49	8.50	10.42	20
Type 304 stainless (welded, Schedule 40)	2.12	3.81	1.84	2.22	17–21
Type 316 stainless (welded, Schedule 40)	2.84	5.31	1.80	2.45	17–21
Carpenter No. 20 (welded, Schedule 40)‖	5.03	9.83	3.12	4.22	17–21

* Dow Chemical Co., Midland, Mich.
† U. S. Rubber Co., Providence, R.I.
‡ H. N. Hartwell & Son, Inc., Boston, Mass.
§ Haveg Corp., Marshallton, Del.
‖ Carpenter Steel Co., Union, N.J.

piping materials currently available can be used for handling water treatment chemical solutions. Table 2 lists these in the order of approximate cost. Some information is shown also for metal piping, to provide a standard of comparison.

It is always misleading to compare the purchase cost of materials, particularly piping materials, when the installed cost is an important consideration. Sometimes a factor of ten in the purchase cost of piping materials may be reduced to a factor of four or less in the installed cost. Installation requirements are all important and frequently the governing factor in the installed cost of piping.

Polythene pipe and tubing, available from several manufacturers, is a relatively new thermoplastic product which has proved reasonably satisfactory for handling many chemical solutions. It is available in either black or natural color. Chemically it is suitable for handling all the solutions that this discussion covers. Its physical properties are relatively unsuitable, however, and it must be supported continuously in much the same manner as is required for lead.

Joints may be made by the use of welded-on flanges, but the cost is currently high. Flanged joints, therefore, are used only when other types are not practicable. The joining of tubing is most commonly done with inserted nipples and hose clamps, but satisfactory joints can be made by welding. When inserts are used, consideration must be given to the corrosion resistance of the insert material. Another method of joining that has given satisfactory results is to use polythene sleeve fittings with a length several times the bore dimension. These are first heated in boiling water and are then forced over the pipe or tubing ends. The ends of the sleeve are then fillet welded to the pipe. This type of connection provides better bursting strength than butt-welded joints.

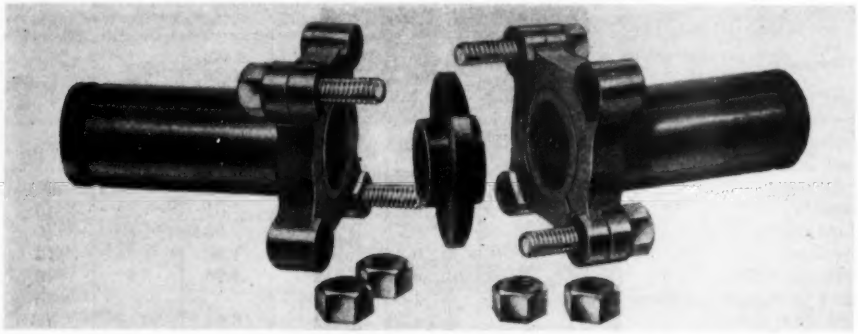

Fig. 3. Joint for Rubber-lined Pipe

Two rubber-lined pipe sections prepared for assembly illustrate the split-flange principle. The rubber gasket fits snugly into the counterbored pipe lining. The split flange has only to be bolted together with a hand wrench to complete the assembly. The joint illustrated is a product of Gates Engineering Co., Wilmington, Del.

Uscolite,* another thermoplastic material, is available as rigid piping in approximately standard iron pipe sizes of ½–2-in. diameter in 10-ft lengths. It has a long-term test tensile strength of approximately 1,200 psi and a relatively good impact strength. It is considered suitable for pressures up to approximately 100 psi at room temperature and is chemically suitable for handling all the solutions discussed. Its upper temperature limit is approximately 170°F.

Uscolite threads readily with standard tools and can be installed in the same way as steel piping. Experience indicates that sealing compounds are not necessary but regular pipe joint compounds can be used satisfactorily. Because most plastic threaded joints have a tendency to stick after assembly, flanged joints with soft rubber gaskets should be used when occasional or frequent dismantling is anticipated. Uscolite pipe requires better support than metal pipe. It is generally recommended that horizontal runs be supported with angle irons or by similar means. When straps are used, the spacing should be at 3–4-ft intervals. Uscolite pipe can be bent fairly easily by heating it to approximately 180°F, bending around a suitable form, and then cooling quickly.

Nonplasticized, rigid polyvinyl chloride thermoplastic materials are now available from several sources as piping in standard sizes of ¾–6-in. diameter in 10-ft lengths. Such pipe has a long-term test tensile strength of approximately 2,000 psi and a relatively good impact strength. It is considered suitable for working pressures up to approximately 100 psi at room temperature and is chemically resistant to all the solutions involved. It can be threaded readily with standard tools and can be installed like steel, except that better support is required.

* A product of U.S. Rubber Co., Providence, R.I.

Plastic Pipe for Water Services

By John N. Spaulding

A paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by John N. Spaulding, Gen. Supt. of Water Systems, Pacific Gas & Elec. Co., San Francisco, Calif.

EARLY in 1951, in an attempt to find a substitute for copper tubing, then in short supply, samples of plastic tubing were obtained and put in the hands of the Pacific Gas and Electric Co. testing laboratory. The first plastic pipe tested was a cellulose acetate type, made of smooth, black, unreinforced plastic. It is manufactured in 20-ft lengths in 1-in. iron pipe size. Its weight is 2.43 lb per 20-ft length, it is quite flexible at normal temperatures (60°F), and it can easily be cut with a hacksaw and threaded with ordinary pipe dies. It was found, however, that the bare pipe could not be threaded. A half-sleeve had first to be cemented over the end of the pipe, and the threads were then cut in the sleeve with a conventional pipe die. Care was necessary to prevent tearing of the threads.

Sleeve couplings were applied by coating the interior surface of the sleeve with solvent and the exterior surface of the pipe with a heavy coat of cement and immediately joining them. After 5 min, the joints could be handled but could not withstand water pressure for 24 hours. Special threaded adapters were applied in the same manner.

Types of Tests

Tests were run on the pipe for the purpose of determining various characteristics:

1. *Bursting pressure and leakage at fittings.* Two sections of pipe were joined with a sleeve and the opposite ends fitted with threaded adapters. One end was capped and the other connected with a high-pressure hand pump. The pipe was tested 5 min and 24 hours after cementing.

2. *Brittleness at low temperatures.* Brittleness at low temperatures was determined as a function of shock resistance, the most severe condition and one that might be expected to give trouble in the field. A ¼-in. hole was drilled in a short section of pipe and a saw cut was made in the pipe transverse to the drilled hole. The pipe was set in a clamp, slotted side up, and placed in a refrigerator with a controlled temperature range of 55° to −10°F. After coming to constant temperature, the slotted pipe was struck a blow with a striker of known energy. The impact load required just to break the pipe at various temperatures was determined.

3. *Brittleness under vibration.* Brittleness under vibration is a function of temperature and will increase in direct proportion to reductions in temperature. As vibration tests are time consuming and difficult to perform at low temperatures, it was considered sufficient to make the test at room temperature and apply a ratio determined from the previous tests for low temperatures.

4. *Distortion at temperatures exceeding 75°F.* In this test, the pipe was assembled as a vertical cantilever beam through which warm water could be circulated. A given load could be applied to the beam for a stated interval and the deflection determined. After release of the load the beam could be checked for permanent set. By varying the water temperature and keeping all other conditions constant, the softening point of the pipe could be determined.

5. *Resistance to weathering.* This action is extremely difficult to simulate, as conditions of service vary so widely. As a substitute a length of pipe was placed in an artificial weathering device, where it was exposed to a continuous atmosphere of rain and ultraviolet light. In addition, one sample was subjected to continuous exposure in an oven at 140°F, and another sample was tested by partial immersion in damp soil in the laboratory yard for a long period. Although none of these tests will provide conclusive evidence of the expected life span, they may serve as indicators.

TABLE 1

Hydrostatic Pressure Test

Pressure *psi*	Diameter *in.*	Swell* *in.*
0	1.126	
50	1.131	0.005
100	1.133	0.007
150	1.135	0.009
200	1.136	0.010
250	1.137	0.011
300	1.138	0.012
350	1.141	0.015
400	1.144	0.018
450	1.147	0.021
500	1.150	0.024
550	1.156	0.030

* Increase in diameter.

6. *Freezing effects.* A section of plastic pipe, filled with water and capped, was broken at −10°F and examined. After examination it was subjected to sudden shock.

Results of Tests

1. *Bursting test.* Table 1 shows the results when a pipe with one sleeve and two threaded adapters was subjected to hydrostatic pressure. No leakage was noted during the test. The pipe burst at 550 psi, a small hole being formed. The yield point of the pipe was approximately 300 psi. Pressure applied to pipe cemented for 5 min resulted in bad leaks.

TABLE 2

Brittleness Test

Temperature °F	Striker Drop *in.*	Energy Required to Fracture *in.-lb*
70	8	10.8
55	8	9.4
45	6	8.1
35	5	7.4
30	4	6.6

2. *Brittleness at low temperatures.* Table 2 shows the effect on a nicked section of pipe clamped at one end and subjected to an impact on the other, while at a specified temperature. These values indicate a straight-line relationship between temperature and fracturing energy, which means that the material must be considered brittle within the temperature range of the test.

From a practical standpoint, it is impossible to predict just what shock a pipe may be required to resist. In nicked (threaded) sections, a relatively light shock such as dropping a Stillson wrench on unsupported pipe at temperatures in the 50°–70°F range might be sufficient to cause fracture.

At lower temperatures, the danger will be progressively greater. In runs joined by sleeve couplings, the danger will be much less and probably not worth considering. The foregoing indicates that a great deal of care must be exercised in handling the pipe at temperatures below 50°F and that sudden shocks should be avoided as far as possible.

3. *Brittleness under vibration.* Tests were made on a section of plastic pipe 24 in. long, containing a threaded adapter and sleeve coupling, arranged as a cantilever beam and threaded into iron pipe. One end was fixed, the other subjected to alternating vibration with an amplitude of 0.1 in. and a frequency of 1,750 cycles per minute at a temperature of 72°F. The condition of the pipe after 1,500,000 alternations was excellent. There was no visible evidence of any cracks. The pipe was subjected to 500-psi hydrostatic pressure after the test, with no leakage resulting.

TABLE 3

Distortion at High Temperatures

Temperature °F	Deflection Under 30-sec Load *in.*	Permanent Set After 1 min *in.*
66	0.984	0.015
73	0.984	0.015
78	1.000	0.015
84	1.000	0.015
92	1.048	0.015
98	1.094	0.015
104	1.375	0.125
109	1.468	0.125
114	1.562	0.125
124	1.938	0.281
145	2.938	0.656
150	continued bend	

4. *Distortion at temperatures exceeding 75°F.* Table 3 shows the extent of distortion in pipe supported as a vertical cantilever with warm water circulating inside. These results indicate a softening point at approximately 95°F and a flow point at 145°F. From a practical standpoint, pipe stored at 95°F would take a permanent set if subjected even to light loads. For bending pipe, it would be preferable to heat it to approximately 150°F and bend it on a long radius. Short bends in the laboratory resulted in kinking of the pipe.

TABLE 4

Comparison of Pressure Test Results

Pressure *psi*	Increase in Diameter—*in.*	
	Tenite II	Cellulose Acetate
0	0	0
50	0.0002	0.005
100	0.001	0.007
150	0.002	0.009
200	0.003	0.010
250	0.004	0.011
300	0.005	0.012
350	0.007	0.015
400	0.008	0.018
450	0.010	0.021
500	0.012	0.024
550	0.013	0.030†
600	0.016	
640	*	

* Burst, fracture being in form of longitudinal crack extending entirely through bell coupling and into pipe on either end. No leakage during test.

† Burst, fracture being in form of small hole blistered out from the pipe.

5. *Accelerated weathering test.* After 3 weeks' exposure in the weathering device previously mentioned (equivalent to 1 year's outdoor exposure), the pipe surface appeared dotted and oxidized, with minute cracks visible. The pipe remained ductile and in serviceable condition. After 5 weeks in an oven at 140°F, there was no visible change in the pipe, which was still ductile and serviceable.

6. *Freezing test.* Water-filled pipe frozen at 0°F gave no indication of

bursting or distress. The pipe was dropped 3 ft to a concrete floor, the capped end breaking off in threads. When struck against a steel beam, the balance of the pipe suffered no damage in the unthreaded section.

Evaluation of Results

It appears that temperature variations during the handling period will cause the most trouble but that, once field crews are trained in handling the material, most of the difficulties can be eliminated. Once the pipe is in service in a covered trench, little trouble is anticipated.

TABLE 5

Comparison of Brittleness Test Results

Temperature °F	Energy Required to Fracture—*in.-lb*		
	Tenite II Actual	Tenite II Weighted*	Cellulose Acetate
75	18.0	23.3	
70			10.8
55			9.4
50	15.6	19.4	
45			8.1
40	12.0	14.9	
35			7.4
30	8.4	10.4	6.6
20	6.0	7.4	

* Because ¾-in. Tenite II and 1-in. cellulose acetate pipe was used, the Tenite II results have been multiplied by 1.24 for purposes of comparison.

Generally speaking, cellulose acetate pipe is resilient under slowly changing stresses at any temperature above 32°F and below 95°F. It is brittle under impact stresses, probably in the full range below 95°F, and is especially susceptible in a nicked section. It has high resistance to bursting stresses and fair resistance to weathering in sunlight (the estimated life in sunlight is more than 1 year). It is subject to plastic flow under sustained load at temperatures greater than 95° F. When the unfavorable factors are balanced against freedom from corrosion, lightness in weight, ease of joining, and ease of handling, a substantial field trial seems justified.

Inasmuch as this cellulose acetate pipe was, at the time, obtainable only in iron pipe sizes and appeared to offer many disadvantages, a further search was made. One of the conditions established was that the plastic tubing must be readily joined without threading and could be used with the corporation stops, curb stops, and meter couplings presently stocked for use with copper tubing.

A transparent plastic tubing extruded from Tenite II Formula 268* appeared to have possibilities. This tubing was available in coils similar to and with the same outside diameter as copper tubing. The following material was obtained: one 20-ft length of 0.875-in. OD plastic tubing with a wall thickness of 0.06 in.; eight pieces of double-bell connector; and eight nipples, flared on one end and straight on the other. In addition, two solvents, reported to be tasteless, were procured for use in joining the pipe. These were diacetone alcohol (acetone free) and methyl cellosolve acetate.†

Tests similar to those previously described were made on this tubing. It was found that the Tenite II plastic tubing could be quickly joined to copper fittings and could be joined to itself by means of bell couplings and put into service within an hour. Comparisons of test results for Tenite II and cellulose acetate pipe are shown in Tables 4–6.

* A product of Tennessee Eastman Corp., Kingsport, Tenn. The pipe itself was made by Kraloy Plastic Pipe Co., Los Angeles.

† A product of Carbide and Carbon Chemicals Div., Union Carbide and Carbon Corp., New York.

TABLE 6

Comparison of Heat Distortion Test Results

Temperature °F	Deflection Under 30-sec Load—*in.*			Permanent Set—*in.*		
	Tenite II Actual	Tenite II Weighted*	Cellulose Acetate	Tenite II Actual	Tenite II Weighted*	Cellulose Acetate
66			0.98			0.015
73			0.98			0.015
74	0.94	0.75		0		
78			1.00			0.015
80	0.94	0.75		0		
90	1.00	0.80		0		
92			1.05			0.015
98			1.09			0.015
100	1.03	0.82		0.006	0.005	
104			1.375			0.125
109			1.468			0.125
110	1.03	0.82		0.009	0.007	
114			1.562			0.125
120	1.375	1.10		0.125	0.10	
124			1.938			0.281
130	1.563	1.35		0.187	0.15	
140	2.00	1.60		0.375	0.30	
145			2.938			0.656
150	3.25	2.60	continued bend	0.625	0.50	continued set
156	3.25	2.60		1.50	1.20	

* In order to provide a uniform basis for comparison, the Tenite II results have been divided by 1.25 to compensate approximately for the difference in net section of the two kinds of pipe.

Evaluation

The physical properties of Tenite II tubing are appreciably better than those of cellulose acetate tubing. The methods employed to make field connections with Tenite II tubing appear foolproof. The flared nipples used to join it with copper fittings are secure up to the bursting pressure of the pipe. The bell coupling connectors provide a more rigid connection than any type of sleeve connector, and the 1-hour drying time using methyl cellosolve acetate appears to be within reasonable limits. (The drying time of the diacetone alcohol joints, 4 hours, seems excessive and it is not recommended.)

On the basis of laboratory tests of the physical characteristics of the material, tubing of Tenite II plastic was adopted for use in water services. A factor that contributed toward the selection of this material was its usage as service pipe by one of the large gas utilities.

Several other plastic pipes and tubing were tested, but, because of unsuitability due to obvious physical defects, they were rejected early in the course of the investigation.

Field Experience

Standards and instructions covering the installation and handling of the plastic pipe selected were prepared, and installations were started in the field. By October 1952 plastic pipe was in use in approximately 300 services, all of them in outlying areas, where failure would not cause too much trouble.

The problem of electrical grounding was met by notifying all water cus-

tomers by mail that plastic pipe was being used in parts of the system. They were informed that they could no longer assume that water service pipe would serve as a suitable ground. This step was taken after discussion with various groups concerned with grounding of electrical circuits. So far there have been no repercussions.

Plastic services have been found cheaper than copper, ¾-in. copper tubing costing 39 cents per foot and ¾-in. plastic tubing, 17 cents per foot. The cost of labor for installation is about the same for both, so that, on an average service of approximately 25 ft, the saving is approximately $5.50.

At first the connection to the copper curb or corporation stop was made by coupling the plastic tubing to a special plastic adapter which was flared at one end to fit the copper fitting. A double-bell coupling was used between the pipe and the adapter. It was soon discovered, however, that, when the coupling fit very tightly over the tubing, a weak bond resulted because the plastic, softened by dipping in the solvent, was wiped off. As the coupling adopted gave insufficient clearance, it was necessary to expand the bell in the field. Later on it was found possible to flare the tubing in the field and thus eliminate the adapter and coupling. (For those interested, portions of the instructions issued by the company for storing, handling, and installing plastic tubing are given in the Appendix.)

The installed services have given no trouble except when attempts by plumbers or unauthorized persons to turn the shutoff cock have caused the tubing to be twisted off. This has happened twice, but it has also been experienced with copper tubing. Freezing weather, heavy rain, and ground settlement may result in difficulties in the future. It is still too soon to draw any definite conclusions regarding life expectancy. Although plastic tubing for water services looks very promising, only time will determine the extent of its usefulness.

APPENDIX

Storage, Handling, and Installation of Plastic Tubing

[Tenite II plastic tubing] has many good properties, [but] it has certain deficiencies when compared to copper. These deficiencies may be overcome to a great extent if care is taken in the storage, handling, and installation.

General data:

Material:	Tenite II plastic
Color:	Clear
Weight:	0.1 lb per foot
Standard package:	450-ft coil
Coil diameter:	6 ft
Flow temperature:	100°F (approximate)
Bursting pressure:	600 psi (approximate)

Storage

Because [Tenite II] is a thermal plastic, it is sensitive to heat and it will begin to soften at 110°F. For this reason the following precautions should be taken in storage: store away from source of heat; store coils flat, not on edge; store indoors, out of sun, and at normal room temperatures. Do not store other materials on top of tube; avoid contact with sharp edges or abrasive surfaces.

Handling

The same procedures will apply in general for handling [plastic tubing] in coils as for copper. Since all plastics will not withstand abrasion, special care should be taken to avoid sharp edges of rocks, truck tail gates, meter boxes, etc.

[Plastic tubing] can be cut most readily with a hacksaw, but a knife will also cut

this material. Shears of any kind should *not* be used. In cutting be sure end is square.

Heavy objects should not be placed on the tubes or fittings and they should be carried on trucks in such a way as to avoid the possibility of heavy tools falling on or striking the material. When [plastic tubing] is in trucks every effort should be made to keep it from the direct rays of the sun, particularly during the summer months.

Jointing

Plastic to copper. [Plastic tubing] can be flared and connected directly to copper fittings. The plastic tubing flares quite readily under normal temperatures (50°F or above) but should be warmed in cold weather. This can be accomplished in several ways, but an open flame should never be used. The method usually used in the field is to place the tubing in the [flaring] tool in the position for flaring. Hold the tool close to the exhaust on the truck until warm to the hands, then make the flare. It is not necessary to get the tool and tubing hot. Excess heat will damage the tube and result in leakage after the joint is made. Field flares should be made just prior to connecting to the corporation or curb stop. The cold-flow properties of plastic tend to cause the flare to straighten out if allowed to stand for any great length of time, and it is important that the flare retain its full width.

Plastic to plastic. [Plastic] tube is connected to [plastic] fittings by use of a plastic solvent called methyl cellosolve acetate. No other solvent is to be used unless these instructions are changed at a later date. The joint is made as follows:

1. Dip the end of the tubing or adapter into the solvent, submerging the end about ¾–1 in. Allow to remain in solvent for 1 min or until plastic becomes soft on the outside. Do *not* allow the plastic to remain in solvent until it deforms. Practice will indicate the required amount of time needed.

2. Remove tubing from solvent and insert into the belled end of the coupling. Push the tubing into the coupling firmly and straight until no further penetration can be made. Do *not* twist or cock tubing in coupling. It will be noted that, even with the solvent having softened the tubing, the connection is a tight fit.

Plastic to standard pipe. The transition from plastic to standard pipe is made by using an adapter sleeve. The tubing is inserted into the adapter sleeve after first dipping the tube into the solvent as described previously. After this joint has set, [the tube is coupled] to the standard pipe.

Trenching

[Plastic pipe] should be bedded in sand or soft dirt free of rocks and gravel. Care should be taken in backfilling to insure that no rock or sharp gravel comes into contact with the tubing or fittings. If this precaution is carefully observed, no failures due to abrasion should be experienced.

Integrating Reclamation and Disposal of Waste Water

By A M Rawn, F. R. Bowerman, and Ralph Stone

A paper presented on Oct. 31, 1952, at the California Section Meeting, Pasadena, Calif., by A M Rawn, Chief Engr. & Gen. Mgr., Los Angeles County Sanitation Dists., Los Angeles; F. R. Bowerman, San. Engr., Los Angeles County Sanitation Dists., Los Angeles; and Ralph Stone, San. Engr., Los Angeles.

THE case for complete divorcement of water reclamation from sewage treatment has been much discussed and well documented (*1–3*). It has been pointed out, and rightly so, that the success of waste water reuse often depends upon the complete freedom of the water reclamation process from the problems and perplexities which plague sewage treatment plants. But, in propounding the need for separating waste water reclamation from disposal, there lies a danger that the instances in which the two may be integrated will be wholly overlooked. This paper proposes to discuss the circumstances which dictate separation and those which permit the integration of waste water treatment and waste water reclamation (Fig. 1).

The phrase "disposal of waste water" connotes a necessity for appropriate works to: [1] receive all wastes which are tributary to such works, at all times, in such quantities, and containing all of the multitudinous constituents which may enter the collection system; and [2] treat this influent to render it suitable for discharge to a stream, ocean, or lake, or upon the ground, in accordance with accepted health, nuisance, and pollution standards.

The concept of waste water reclamation differs in that the purpose of such a process is to produce a water source suitable for reuse. To achieve this end, it may be necessary to segregate wastes which are susceptible to treatment and reuse, from wastes which would render the final product unusable. In metropolitan areas such as Los Angeles, yielding large quantities of industrial wastes, this requirement clearly dictates a dual system of sewerage to provide adequate ocean disposal for highly mineralized industrial wastes while permitting the reuse of low-mineral industrial and domestic wastes. On the other hand, small towns or cities which are almost exclusively residential are usually free from the problem of highly mineralized effluents, and waste water reclamation is thereby greatly simplified.

The classification of a given project under waste water disposal or waste water reclamation depends on whether the reclamation and reuse of the waste water is merely incidental to the whole scheme of disposal or is planned as an integrated component of the disposal process. Much waste water has been disposed of to the land and to streams, and thereby restored to use, even though there was no reclamation in-

tended; this is termed incidental water reclamation. By contrast, planned water reclamation starts with a predetermined use for the water and, working backward, evolves the optimum process that will provide the quality of effluent necessary. Integrated reclamation of waste water is defined as the combining, planning, and controlling of treatment and reclamation of waste effluents for maximum reuse at minimum cost for treatment.

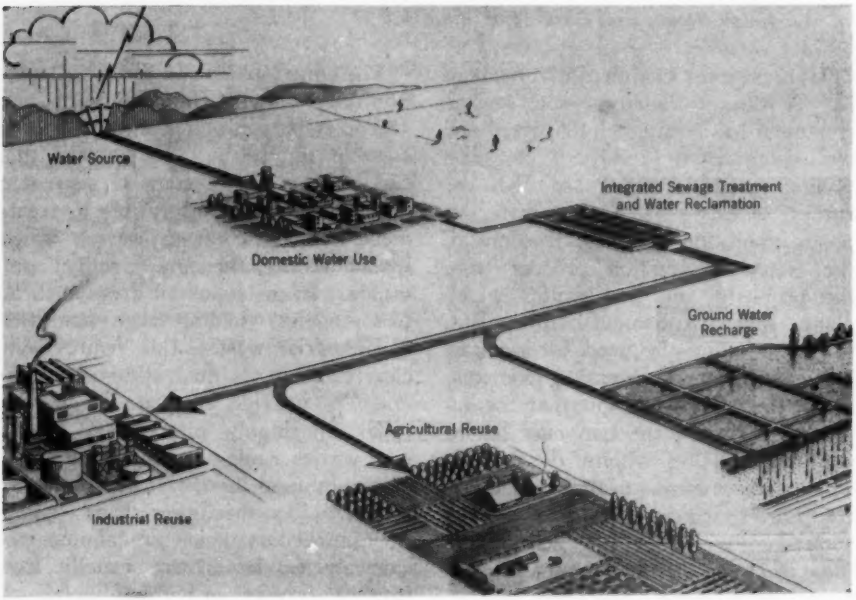

Fig. 1. Integration of Waste Water Disposal and Reclamation

Where surface water supplies abound, the final disposal of sewage effluents is usually effected by dilution in streams, rivers, or lakes. In the southwestern part of the United States, however, surface waters are virtually nonexistent during the greater portion of the year and final disposal must be made on the land, except in coastal areas. The factors pertaining to successful land disposal of sewage effluents have not been completely understood, but in the last 3 years extensive studies have been made by the Sanitary Engineering Research Project, University of California, both at Los Angeles and at Berkeley, on the fundamental principles of land disposal. Planned water reclamation has lagged because engineering knowledge has been inadequate to enable sanitary engineers to develop land disposal systems logically. The results of the university studies should assist engineers to plan intelligently toward the maximum use of waste waters at the minimum cost for sewage treatment (*4*).

Economic and Quality Problems

The most common reason given for not reclaiming waste water is the availability of an inexpensive, adequate supply of raw water. On first thought,

TABLE 1

Comparative Costs of Reclaimed and Other Water Supplies in the Los Angeles Metropolitan Area

Type of Sewage Treatment	Cost of Treatment $/acre-ft	Possible Uses
Activated sludge process Trickling filter process	10–20	industrial cooling and quenching process water fire protection agricultural ground water recharge
Primary sedimentation and oxidation ponds	4–8	industrial cooling and quenching process water fire protection agricultural ground water recharge
Primary sedimentation	3–5	agricultural (restricted use) ground water recharge
Water Supply	**Cost (Before Distribution) $/acre-ft**	**Possible Uses**
Metropolitan Water Dist. (softened Colorado R. water)	25 (minimum)	unrestricted
Los Angeles Dept. of Water and Power	17.50 (Owens R. water) 8–12 (local ground water)	unrestricted

this factor might rule out water reclamation in such areas as a feasible enterprise. The criterion should, however, not be simply the cost differential between a natural and a reclaimed water supply. The costs of waste disposal must continue to be borne regardless of the use or nonuse of the effluent. In determining reclaimed-water costs, it is reasonable to assume that part or all of the cost of disposal may be assessed against the disposal operation, with only those charges in excess of the disposal cost being assessed against the final water user. The relationship between waste water reclamation costs and those for other water supplies in the Los Angeles metropolitan area is indicated in Table 1.

At Baltimore, the Bethlehem Steel Co. uses the effluents from the Baltimore sewage treatment plant in steel production. The steel company pays only those costs of processing in excess of that required for normal disposal, plus all costs for pumping and distribution to the point of use. In this manner, the cost of the reclaimed water is significantly less than that of other water sources. It seems reasonable to assume that Baltimore should continue to pay those costs which are required for the disposal phase.

Most domestic water supplies are pumped from the ground or taken from surface sources without appreciable concentrations of mineral constituents. Domestic use of water may increase the mineral content by an

TABLE 2

Mineral Content of Certain Industrial Wastes *

Industry	Hardness ($CaCO_3$) *ppm*	Chlorides *ppm*	Dissolved Solids *ppm*	Alkalinity ($CaCO_3$) *ppm*	SO_4 *ppm*
Oil refinery					
Raw-water supply	96	60		266	104
Cooling-tower waste	360	572		56	2,240
Boilerhouse residual and blowdown	87	484	1,424	1,255	
Asphalt processing plant	97	634		400	47
Railroad yard (passenger car and diesel locomotive washings, etc.; after treatment for oil removal)	168	85		122	256
Brewery (bottle-washing waste)			4,000	3,260	
Oil field brines					
Example A (3.5 mgd)		6,000	11,450		22
Example B (3 mgd)		16,400	26,945		0

* Based upon analyses submitted to the Los Angeles County Sanitation Dists. by the industries.

average of 100–300 ppm of dissolved solids. Industrial use may or may not increase the mineral content; sometimes dissolved solids may increase to as much as several thousand parts per million, raising salinity and hardness so high that any possibility of the reuse of such highly mineralized waters is ruled out (Table 2). Where water supplies are initially high in mineral content, the reuse of waste waters may be less feasible than otherwise.

Health and Public Antipathy

In addition to meeting the tests imposed by economics and mineralization, the reuse of waste waters must meet the tests of health and public antipathy. Health restrictions have been imposed on the reuse of sewage effluents for very good reasons. Domestic sewage contains pathogenic organisms which are potential sources of disease (*5*). Broadly speaking, these health considerations prevent the use of reclaimed sewage in any food processing and define certain limitations on agricultural irrigation practices.

Crops which are not utilized directly for domestic consumption or from which there exists no possibility of direct transfer of disease to animals or humans can be irrigated with primary sewage effluents, provided engineering and health principles are observed. Unrestricted crop uses demand well-oxidized, sterilized effluents with essentially the same standards as for potable water. It is apparent that processes involving partial treatment, such as primary sedimentation, will usually result in lower overall costs than would be true for crops irrigated in such a manner as to require an effluent which will meet potable water standards. To prevent the development of a situation in which the final use of an effluent is not commensurate with the degree of treatment, it is good practice to place the supervision of the final use under the same agency that controls the sewage treatment operation.

Public antipathy toward sewage reclamation, whether justified or not, is a very real problem in locating reclamation works. The prejudices against sewage treatment facilities carry over with no loss of intensity to include reclamation plants. Wherever possible, sewage reclamation plants should be located to minimize complaints about possible odors, insects, and other such nuisances. The proper operation of sewage treatment and water reclamation plants depends upon good engineering practices. Experience has clearly shown that such operations can be made acceptable.

Oddly enough, one of the factors which can limit the reuse of waste water in a large metropolitan area is an extensive sewage collection system, which may cover hundreds of square miles and which concentrates large volumes of sewage in areas where limited demand exists. To utilize the reclaimed effluent, it is necessary to transport it to places where it may be used. This may require the construction of separate piping systems to keep reclaimed waste waters from mingling with domestic water supplies. These additional costs, plus the cost for continual pumping, narrow, and sometimes completely eliminate, the margin of economy that exists between reclaimed water and other water supplies. Exceptions exist where metropolitan centers are located upstream from industrial or agricultural water users, but in places where the sewage is collected and treated at a lower elevation it is usually not practical to pump reclaimed waste water upstream to distant areas for reuse.

More desirable would be the location of reclamation plants in various upstream areas, where domestic sources of sewage permit simple treatment, with subsequent discharge at elevations above agricultural or industrial users, who then receive the effluents by gravity flow. Parenthetically, it should be observed that large metropolitan centers usually impose ground water shortages upon themselves because of high industrial and domestic demand. Owing to the high cost of water, caused by scarcity, it is sometimes feasible to go to greater extremes in the reclaiming of waste waters in such areas, where otherwise such proposals would not be considered economical.

Seasonal fluctuations in the demand for water, particularly for agricultural use, impose certain limitations. The mandatory disposal of all collected wastes makes it difficult to integrate the operation with a varying demand for reclaimed waste water. This conflict can be resolved by providing alternative disposal facilities to treat excess quantities of sewage during that portion of the year when irrigation requirements are reduced.

Irrigation and Recharge

In many places, domestic water sources are developed only with considerable difficulty and expense. Agricultural development of land in such areas is uneconomical because of the high cost of irrigation water. Desert areas in the southwestern part of the United States, having alkali soils, can often be reclaimed for agricultural purposes, provided cheap and abundant water supplies can be found. Through planned integration of reclamation and disposal of waste waters, a constant supply of relatively inexpensive irrigation water, augmented with significant fertilizer values, may be provided for these water-short areas. This will also hold true for industrial use of reclaimed water in water-short areas that otherwise might not be able to support wet industries.

Fig. 2. Irrigation Use

Where waste water reuse entails spreading-basin infiltration, further economies can be obtained by taking full account of the oxidation which is accomplished in the spreading basin. Effluents discharged to spreading basins require less treatment than if discharged to a small stream or stream bed, as the spreading basin acts as a continuation of the treatment plant oxidation process. The irrigation of orchards or pasture lands ordinarily does not require well-oxidized effluents, and, by integrating the final water use with the degree of sewage treatment needed, the process can be made considerably less expensive than if complete oxidation were achieved in a sewage treatment plant. An example of such integrated reclamation and disposal processes is found at Santa Maria, Calif., where the effluent from a trickling filter sewage treatment plant is utilized in the local high school 4-H project in irrigating crops and pasture for pigs, cows, and other domestic animals. At Fresno and Bakersfield, Calif., city-owned farms are irrigated by primary effluents. At Acton, Calif., the effluent from the trickling filter is used for pasture irrigation at the sheriff's honor farm (Fig. 2), while at Azusa, Calif., the effluent is discharged to spreading basins for return to the ground water (Fig. 3). Many other examples of such installations might be cited.

It is apparent that integrated reclamation and disposal may be found most feasible in the smaller, isolated cities where there is a concurrence of the following factors: [1] raw water supplies are scarce and expensive; [2] agricultural demand for irrigation water is high; [3] sewage is largely of domestic origin and, hence, of satisfactory mineral quality; [4] sewage treatment can be made simpler and less expensive through the utilization of reclamation processes which act as a continuation of the oxidation process; and [5] the volume of sewage is relatively small and can be used in areas near the treatment plant.

Ground water recharge and industrial reuse of waste waters may be feasible in metropolitan centers where agricultural reuse is limited. Many industries have learned to reuse process and cooling waters within their own plants, achieving an integration

Fig. 3. Azusa Infiltration Basin

of reclamation and disposal to their economic advantage. The new Lever Brothers plant in Los Angeles is a working illustration of good water reclamation practices which decrease initial raw-water consumption and minimize the quantity of water discharged to sewers. Initial estimates indicated that 20–30 mil gal of water would be wasted daily; through proper engineering design, however, the total discharge from the $25,000,000 plant has been reduced to less than 1 mgd. Here is planned water reclamation, integrated into the very heart of the production processes of an industry. A recent proposal by the Shell Chemical Co. to utilize the flow from the Ventura, Calif., primary sewage treatment plant in the manufacture of ammonium compounds may further demonstrate the possibilities inherent in integrated reclamation and disposal (Fig. 4).

Industrial wastes are not necessarily highly mineralized. On the contrary, many industrial processes increase the mineral content of the water very little.

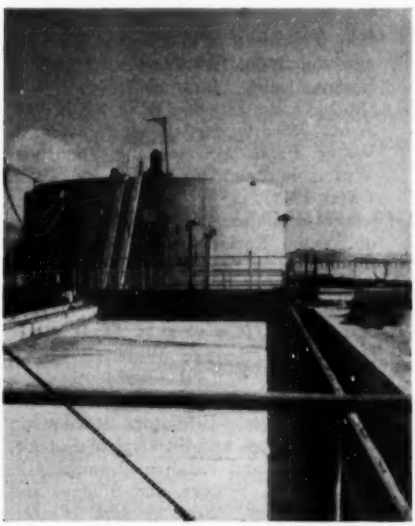

Fig. 4. Ventura Sewage Treatment Plant

Fig. 5. Waste Water Lagoon

Where such conditions exist, there is an excellent chance to integrate the reuse of such waste into the final disposal process. An example is found at Pomona, Calif., where the Fernstrom Paper Mill has devised a simple, but effective, reuse of the process waters. Recycling and internal reuse of process water finally reaches the point where the wastes must be discharged from the plant for disposal. The wastes are discharged to a lagoon, where part of the water percolates into the soil (Fig. 5) and the rest is subsequently pumped to citrus groves for irrigation. The layer of paper pulp remaining after the water has percolated into the ground is plowed into the soil to become an organic mulch.

Each reclamation proposal must be studied and designed around the factors involved. In such planned projects for integrating the reclamation and disposal of industrial waste water, several benefits can usually be realized: [1] a reduction in the raw-water demand for industrial processing, through

internal reuse; [2] a lessened cost for waste treatment, through integration with a reuse process that continues and completes the oxidation; [3] restoration of economic value to the reused water, equivalent to the cost of obtaining such water elsewhere; and [4] a return of all, or a portion, of the waste to ground water for future withdrawal, in those instances where irrigation or spreading is the final step.

Summary

1. The treatment and disposal of waste water is the processing of liquid wastes to render them suitable for final discharge to streams, oceans, lakes, or ground.

2. Reclamation of waste water connotes the production of water suitable for reuse.

3. Integrated reclamation of waste water is defined as the combining, planning, and controlling of treatment and reclamation of waste effluents for maximum reuse at minimum cost for treatment.

4. Integrated reclamation often depends upon successful land disposal, particularly in the southwestern part of the country. Factors pertaining to land disposal of sewage effluents have not been well understood, but recent studies should assist in future planning.

5. Costs for waste water disposal must continue to be borne regardless of the use or nonuse of the effluent. Charges for the use of a reclaimed water may be employed to reduce costs of disposal, but need not defray the total cost of treatment.

6. Agricultural development of land in water-short areas may be made feasible through the use of inexpensive reclaimed waste waters.

7. Ground water recharge through spreading-basin infiltration should take full account of the oxidation achieved in the spreading basin to reduce the degree and cost of initial treatment.

8. Integrated reclamation and disposal will be found most feasible in smaller, isolated cities where raw water supplies are scarce and expensive, agricultural demand for irrigation water is high, sewage is of proper mineral quality, sewage treatment can be made simpler and less expensive through the utilization of reclamation processes which continue the oxidation process, and the volume of sewage is relatively small and can be used in areas near the treatment plant.

9. High mineralization in some industrial wastes may prevent their reuse; however, many industrial wastes are subject to reuse with simple treatment. Water reclamation in industry should be integrated into the production processes; in this manner industries may materially reduce their demand for raw water and minimize waste disposal requirements.

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Problems and Progress in Reducing Phenolic Tastes

Panel Discussion

A panel discussion presented on June 18, 1952, at the Pennsylvania Section Meeting, Erie, Pa. This presentation has been synthesized from the original statements of the participants and is introduced by the moderator of the discussion.

Introduction—*R. B. Adams*

An opening statement by R. B. Adams, Supt. of Filtration, Wilkinsburg-Penn Joint Water Authority, Wilkinsburg, Pa.

INDUSTRIAL-waste pollution of surface streams and ground water supplies has reached a point of great magnitude in certain areas of the United States. Outstanding developments in the field of water treatment and industrial-waste treatment have made possible a satisfactory solution in many locations where cooperation between all parties concerned was at a high level. Unfortunately, the lack of cooperation and coordination has often slowed down progress to a noticeable degree. The difficulty has been evident to the controlling state and federal agencies, which have taken positive action to improve the situation. One notable example is the organization of the Ohio River Valley Water Sanitation Commission. Much credit should go to this agency for the splendid work it is doing.

This panel brings together representatives of water companies, industry, and state and federal agencies. It is hoped that the material presented will help to provide a better understanding of the problems involved.

Phenolic Tastes in a Surface Supply—*F. W. Bouson*

A paper presented by the late F. W. Bouson, Chemist, South Pittsburgh Water Co., Pittsburgh, Pa.

Underlying a large area of the Monongahela River watershed are vast deposits of bituminous coal. A large percentage of the tonnage mined from the soft coal deposits is utilized by the several by-product plants located on the banks of the Monongahela River. The destructive distillation of this coal by the by-product plants produces much of the coke used in the steel industry located in the vicinity of Pittsburgh, Pa. Not only is coke produced in this process, but other valuable and useful compounds as well. The organ-

ics recovered are basic in the production of many items.

In the by-product or chemical plants working with organic derivatives from coal, a minor portion of the effluent may escape through leakage, spillage, seepage, or intentional discharge by irresponsible persons. These losses contain phenols or phenol-like compounds. On reaching the river in sufficient quantities, the by-product compounds present a pollution problem to the water companies using the river as a source of public supply. The resulting phenolic (caused by phenols or phenol-like substances) tastes and odors in the drinking water cause more complaints from the public than any other defect confronting a water company.

The South Pittsburgh Water Co. uses the Pittsburgh pool of the lower Monongahela River as its source of raw-water supply. On too many occasions during the past 25 years the concentration of by-product compounds in the lower Monongahela River water has been large enough to cause phenolic tastes and odors in the effluent of the purification plant. The company furnishes water for all purposes to 70,000 customers and an estimated population of more than 350,000.

The South Pittsburgh Water Co. was the third plant in the United States to experiment with activated carbon and the first to use this product as a continuous treatment. The experimental work dates back to 1930. Since 1949 chlorine dioxide has also been used, in the filtered water, and a more complete removal of phenolic tastes has been accomplished.

Control Methods

In order to keep constant watch over the quality of water in the Pittsburgh pool of the Monongahela River, a daily collection system has been maintained at strategic points on the river. Samples are also collected daily, or more often if necessary, from the sewer discharges of the several large by-product and chemical plants on the watershed. These discharges have, in the past, contained phenol or phenol-like substances in large quantities. It is estimated that more than 85,000 samples have been collected and processed for by-product tastes and odors by the South Pittsburgh Water Co. laboratories. The entire cost of this procedure has been borne by the water company.

The method used in the laboratory for processing the taste and odor samples is simple and rapid. After being collected they are quickly brought to the laboratory. The size of the sample to be processed has been standardized to give comparable results. In all river and purification plant samples, 600 ml is used for the taste and odor determination. A smaller portion—200 ml—of the by-product and chemical-plant sewer discharge samples is used, as these may contain a larger concentration of phenol-like compounds. The samples are placed in 1,000-ml distilling flasks, and sufficient chlorine solution is added to produce a chlorine residual of approximately 0.2 ppm. This chlorination is an added safety factor in tasting the distillate. Slow distillation is necessary to prevent carryover and to insure a cool and complete distillate. As all taste- and odor-producing compounds, including phenol-like substances, are completely distilled over in the first 100 ml, distillation of the sample is stopped at this point. After thorough mixing, the 100-ml distillates from the river and

purification plant samples will contain a sixfold concentration of taste- and odor-producing compounds, while the concentration in the distillates from the sewer discharge samples will be doubled. The distilled and chlorinated samples may be confidently analyzed for taste.

Whenever a sewer sample is found to contain a concentration of by-product compounds sufficient to cause a taste or odor that would be detected readily and that might cause the water to be regarded with disfavor, the plant or chemical company discharging this pollution is immediately notified and requested to look for the cause and correct the condition. If the desired improvement is not noted in the sample collected the next day, the district office of the Pennsylvania Dept. of Health is informed and its cooperation is requested in seeking abatement of the nuisance.

The program of sample collection and analyses for phenolic tastes and odors has stopped at its source many polluting discharges which, if allowed to continue, would have caused serious taste troubles. Through routine sampling, advance knowledge is also obtained of the taste and odor qualities of the Monongahela River that the water purification plant will have to treat in the near future.

Results Obtained

The South Pittsburgh Water Co. has worked in close conjunction with the Pennsylvania Dept. of Health in a combined effort to eliminate the spasmodic pollution of the Monongahela River with by-product tastes and odors. Many conferences have been held with industrial officials in an appeal for their help. In every instance, cooperation was promised. Often the pollution was unknown to the producer and represented a considerable loss of valuable compounds.

Complete elimination of by-product or phenol-like pollution has not been realized, although a reduction in the number of pollution incidents has been accomplished. During the past 25 years there have been long periods in which no phenolic tastes and odors were present in the effluent of the purification plant. A similar period of 3 years' duration was experienced in the late 1940's. The absence of a concentration of phenol-like substances in the lower Monongahela River for such a lengthy period is mute evidence that the river can be kept free from such taste- and odor-producing compounds.

Phenolic Tastes in a Well Supply—*D. E. Chase*

A paper presented by D. E. Chase, Mgr., Munic. Authority of Borough of West View, Pittsburgh, Pa.

The pumping station and softening plant of the Municipal Authority of the Borough of West View, Pa., is located on the upstream tip of Neville Island, approximately 5 miles below Pittsburgh.

The water supply is obtained from 54 wells, including: 28 driven wells located in the main channel of the Ohio River, all connected to a common header; 19 driven wells located in the back channel of the river, all connected

to a common header; 6 gravel-packed wells; and 1 radial collector well.

The Allegheny and Ohio river valleys are underlaid with an unconsolidated deposit of sand and gravel which appears to be covered in the river area with a layer of silt that prevents any rapid infiltration of river water into the undergound deposit. This sand and gravel deposit is an excellent aquifer and serves as a source of water supply for many communities, industries, and commercial establishments. During the past few years the number of wells has increased tremendously, owing primarily to industrial and air-conditioning use and partially to increased public use.

The water obtained from the wells usually differs from the river water at any given moment, but follows in general, with considerable lag in time, the chemical characteristics of the river water.

It is believed a substantial amount of the ground water is recharge from the rivers, the amount of this recharge being subject to the permeability of the so-called protective layer of silt, the depth of the layer, the drawdown in the wells, and other such factors. During recent years the drawdown in practically all of the wells has been excessive. These physical conditions indicate that river water probably enters the ground water. Consequently, phenols in the river water could have a serious effect on the quality of the ground water.

Three or four municipal well supplies several miles below Neville Island have exhibited phenolic tastes since 1949 and it has been necessary to apply chlorine dioxide.

Phenolic tastes were first noticed in the West View supply in September and October 1950. In the latter part of July 1951 the taste was hardly discernible, but it became progressively worse and steps finally had to be taken to eliminate or minimize the condition. Analyses of samples from each well showed phenols varying in concentration from a trace to 0.35 ppm. It appeared that, when the phenol concentrations were low, the tastes were not noticeable at the plant or in distribution system areas near it but were quite noticeable in the dead-end areas. When the concentration became excessive the tastes were noticed all over the system.

Treatment and Control

Chlorine dioxide treatment required 10 lb of sodium chlorite per million gallons of water to remove the taste completely. The phenolic content gradually decreased during the winter and in June 1952 required only 1–2 lb of sodium chlorite per million gallons.

A high dosage of chlorine dioxide produces a breaking or sloughing off of the iron and manganese in the distribution system, resulting in red water, which can cause as many, if not more, complaints as the presence of taste and odors. When red water developed in the West View system, the dosage was immediately lowered even though all the taste was not removed. At the peak phenol concentration, the cost of chlorine dioxide treatment averaged \$45–\$50 per day, or approximately \$7 per million gallons of water.

The presence of phenols and allied compounds in a public water supply presents a serious problem to the water works. It results in condemnation by the general public, causing it to doubt the ability of the water department to operate properly, and certainly tends

to destroy good public relations. The treatment of public water supplies to remove phenolic tastes and odors is not the answer to the problem. It is of paramount importance that the source of phenols be eliminated. Immediate action must be taken by industry to prevent or lessen the discharge of phenolic wastes. Ten years have passed since industry in the area was notified to take steps to abate such pollution.

From a practical operating standpoint, it is difficult for small water plants to treat water for phenols because of fluctuations in concentration, difficulties in making chemical determinations, and similar factors.

Pennsylvania Health Department Survey—*R. W. Kremer and R. J. Cunjak*

A paper presented by R. W. Kremer, Dist. Engr., Pennsylvania Dept. of Health, Greensburg, Pa., and the late R. J. Cunjak, Advanced Chemist, Pennsylvania Dept. of Health, Harrisburg, Pa.

In the Pittsburgh metropolitan area there are a number of large by-product coke and chemical plants which produce waste waters containing phenols and other aromatics notable for their taste and odor characteristics. Although the water companies taking water directly from the Monongahela, Allegheny, and upper Ohio rivers normally are not seriously troubled with phenolic tastes and odors, during periods of low stream flow and cold weather taste and odor problems become more severe. Accidental spills from industrial plants have caused trouble from time to time.

Below the South Pittsburgh Water Co. intake on the lower Monongahela River and the Pittsburgh intake on the lower Allegheny River, there are only two public water supplies within the Pittsburgh metropolitan area which take their supply directly from the major rivers. Other public supplies, as well as many industrial and commercial establishments, generally get their water from the alluvial deposit under the main rivers. This underground supply is usually treated for the removal of hardness, iron, and manganese and is chlorinated prior to distribution. Since 1951 complaints have been received about tastes and odors in the underground supply. The condition was intensified by the extreme dry weather occurring between the months of July and November 1951.

Results of Survey

On Jan. 21, 1952, representatives of various water companies in the Pittsburgh district met with representatives of the Bureau of Sanitary Engineering, Pennsylvania Dept. of Health, to discuss plans for a survey of the surface and well waters in the area. The survey was to include both phenol and odor determinations. Sampling stations were located at the mouth of the Allegheny River, at the mouth of the Monongahela River, and at two points on the upper Ohio River. Sampling stations were also located at a number of water company and indus-

trial plants using the underground supply.

Threshold odors were determined in accordance with *Standard Methods*. Phenols were determined by the modified Gibbs method without distillation. The same chemists were employed for all determinations.

Detailed tabulation and analysis of all the data accumulated are too voluminous to incorporate in this report. The general conclusions reached were:

1. The phenol concentration averaged 0.019 ppm on the lower Allegheny River, 0.054 ppm on the lower Monongahela River, 0.027 ppm on the Ohio River after mixture of the Allegheny River and Monongahela River waters, and 0.031 ppm at the Sewickley Bridge on the Ohio River.

2. The phenol concentration in the various well waters ranged from 0.0 to 0.07 ppm. The phenol content in the well waters changed as the phenol content of the river water increased or decreased, with a lag of 1–2 days.

3. It is suggested that phenol is not detected chemically in the water company wells when the phenol content of river water is below 0.02 ppm.

4. At least one of the industrial wells showed evidence that would indicate local pollution from the owner's plant wastes.

5. The intensity of chemical odors in unchlorinated river and well samples does not necessarily fluctuate in direct proportion to the phenol content. Odors may arise from aromatic and numerous odor-producing substances other than straight phenols.

6. Results of the present survey, as well as of previous studies, indicate that the underground supply receives considerable quantities of recharge water from the streams.

Progress in Industry—*G. A. Pettit*

A paper presented by G. A. Pettit, Ind. Waste Control Engr., Armco Steel Corp., Middletown, Ohio.

The scope of the taste and odor problem has enlarged with industrial expansion, the creation of new types of industry, and the increased use of surface waters. It is necessary that everyone concerned fully understand the difficulties involved, particularly with regard to small concentrations of polluting substances coming from a multiplicity of sources.

The Ohio River Valley Water Sanitation Commisson has recognized the need for cooperation by industries located in the Ohio River Basin. This policy of cooperation led to the formation of the Steel Industry Action Committee, composed of representatives of ten major steel producers in the basin. Realizing the vast complexities of the overall pollution problem, the committee allocated specific aspects to various subcommittees. The function of one of these subcommittees is to study coke plant wastes, the chief contaminant in which is phenolic substances.

Phenols have long been recognized as a serious problem by the coke-producing industry. Through improvements in operation and process changes, the major portion of the pollution load has been eliminated. The treatment of the remaining small pol-

lution residuals remains a problem. From a review of the literature and preliminary investigation, it was found that complete and accurate information on this subject was lacking. Therefore, the program of this subcommittee was set up in two phases: first, to define the pollution problems in the by-product coke industry; and, second, to determine the effects of these wastes.

The first stage of the program was to cover plant operations; sources, concentrations, and volumes of waste; and possible changes in plant operating, processing, and treatment methods to reduce waste loads. The second stage was to cover taste and odor levels, toxicity, analytical techniques and sensitivities, stream purification capacity, and costs of treatment to achieve various degrees of purification. It is felt that, upon completion of this program, the basic data will be available to permit objectives to be developed.

First Phase

The first part of the program has been completed. In order to obtain the data necessary to define the problems accurately, complete surveys were made of seventeen plants located in the various states of the Ohio River Valley. These plants produce approximately 80 per cent of the by-product coke in the basin, with approximately 84,000 tons of coal coked per day. A definition of the problems at each plant has resulted, as well as a comparative summary of operating practices. Each operation was reviewed, thus providing information on how individual plants are handling various wastes. A number of in-plant changes which have taken place since the start of the program have resulted in reducing the phenol load to the streams.

It can be stated that the survey brought out the wide variations in volume and analysis of the few remaining wastes. This fact has seemingly not been realized by those outside the industry. The variation reflects the differences in the processes and materials used in making coke in the seventeen reporting plants. The age of the reporting plants varies from 1 to 40 years. Improvements in plant design during those years have reduced the volumes of contaminated wastes. Coals vary in both chemical composition and physical characteristics from mine to mine and in the different sections of the same mine, the variations affecting the quantity and quality of waste liquor produced. Blast furnace operations require different types of coke to make the various kinds of pig iron used in steel production. The desired types of coke are produced by varying the raw materials and operating conditions, such as temperature and coking time, again affecting the quantity and quality of the wastes. Therefore, with the best operating practice, the control of the quantity and quality of wastes produced is limited by the design of the plant, the raw materials used, and the coke requirements.

A complete study of the various treatment methods in use was made, including some which have been tested in pilot plants and others still in the laboratory stage. For example, the processes designed to treat ammonia liquor or ammonia still wastes for the removal of phenols were studied. Approximately 98 per cent of the phenol content of ammonia wastes has

been removed by the use of dephenolizing towers. In addition to the large investment required, this process involves high operating costs for labor, reagents, and power. Disposal by coke quenching also removes practically all phenols but is very expensive owing to the corrosiveness of this waste. Because residual phenol content remains in the still wastes, some additional treatment method must be developed. Various methods were studied, such as chemical oxidation with chlorine, ozone, and chlorine dioxide; absorption by activated carbon in froth flotation cells; and biological oxidation. It must be emphasized that not one of these treatments offers a complete solution for the removal of all residual phenol.

Second Phase

The second part of the program, on which the committee is now working, includes the effects of the wastes from coke plants on water quality. It promises to be a heavy task and will require the assistance of many agencies and individuals. The study of tastes and odors produced by phenolic wastes presents a number of practical questions: How big a part does phenol play? What other substances are producing phenolic tastes and odors? What are the actual water users' requirements and how closely can they be met? To find the answers, the committee expects to work very closely with the Water Users Committee, set up by the Ohio River commission, and with state agencies. A study of the toxicity of the wastes is being carried on under the commission, with the assistance of the various industrial action committees.

Analytical techniques must be improved upon and standard procedures determined for the low ranges of phenol involved. A detailed study of methods for phenol analysis has been carried on by the member companies for the past year. The results of the work indicate that the distilled 4-aminoantipyrine (DAAP) method is rapid, detects all phenols, and is sensitive down to 0.1 ppm. The U.S. Public Health Service has developed a sensitized technique with the DAAP method for the low ranges of taste and odor encountered in the receiving bodies of water.

This phase of the committee's program is of such importance that it is asking the assistance of the various state health departments and the U.S. Public Health Service. As methods are field tested and proved practical, and as new techniques are developed to meet the requirements, these departments will review them.

Although the U.S. Public Health Service has done some work on stream purification capacities in regard to phenol, a great deal more information is required before conclusions can be drawn. The committee has instituted two surveys to determine the capacity of streams to remove phenols by self-purification. One of these surveys is on a clean stream with no sewage, the other on a stream carrying raw sewage. Through further study of the various treatment methods, it is hoped to develop data on the cost of treatment to achieve various degrees of purification. Because of the many variables in plant design, this promises to be a difficult problem. Considerable progress has been made, but, until the program is completed, the basic data necessary to develop objectives

and determine the types and degrees of treatment required will not be available.

The steel industry is also continuing to carry on experimental work to develop new methods of treating phenolic wastes. Other industries are investigating the treatment of their phenolic wastes. The correlation of all this information through the cooperation of the various industries and regulatory agencies will most certainly lead to the equitable solution of mutual problems.

Ohio River Sanitation Commission—*J. E. Kinney*

A paper presented by J. E. Kinney, San. Engr., Ohio River Valley Water Sanitation Commission, Cincinnati, Ohio.

The Ohio River Valley Water Sanitation Commission has not yet established a limit on phenols. Before doing so, the commission is evaluating every factor having a bearing on phenol discharges, self-purification capacities of streams, sensitivity of analytical techniques, taste and odor levels, and methods of treatment. To be useful an objective must be realistic, attainable, and able to give the desired results.

Methods to destroy trace residuals of phenol in coke plant wastes are being developed, but the availability of treatment methods is only part of the story. The variability of phenolic wastes and the variety of sources require a knowledge of the applicability of these methods to the individual wastes.

Advisory Groups

The major sources of phenolic wastes in the Ohio Basin include the steel, oil-refining, and chemical industries. The commission, recognizing the complexity of industrial-waste problems, wrote into its statement of policy that it would seek the cooperation of industrial groups in developing requirements for the treatment of industrial wastes. In 1950 the steel industry agreed to supply company management representation on a committee that would pool resources and knowledge to outline the waste problems within the steel industry, evaluate methods of treatment available, and work with the commission to develop data on the effects of steel industry wastes. The activities of that committee have already been described.

An exploratory conference was held on June 30, 1952, with representatives of the oil-refining and organic-chemical industries to establish additional committees. Much of the work that has been done by the steel industry group will be of immediate use to these new committees.

Tied in with these committees are the activities of the Water Users Committee, composed of water treatment plant operators, both municipal and industrial, who use the Ohio River as a source of supply. Information on taste and odor levels is thus available to the industry committees.

In addition, the Ohio River commission has two other advisory groups that will help establish the basis for the control of industrial-waste discharges. The first is the Kettering

Laboratory of Applied Physiology at the University of Cincinnati. The project established there by the commission is intended to develop information on the cumulative effects of wastes on man and animals. The toxicological properties of wastes, either alone or in combination, are being determined.

The second advisory group is a committee of outstanding aquatic-life biologists. The Ohio Basin Compact calls for waters that are suitable for maintaining fish and other aquatic life. This group is aiding in the establishment of criteria for defining that requirement.

The commission will set water quality objectives with the aid of its various advisory groups. Representatives of the industry committees, the Water Users Committee, the Aquatic Life Advisory Committee, and the Kettering laboratory will be able to supply the required information on the sources of waste and its effects on subsequent water uses, and will evaluate available methods of treatment with respect to physical and economic limitations.

Nonphenol Tastes

Complicating the problem of phenolic tastes and odors is the fact, evidenced by findings of the U.S. Public Health Service, that substances other than phenols create "phenolic" tastes. Carbon filters have been used to collect and concentrate the taste- and odor-producing substances found in the water supplies of several communities. The individual compounds in the residue taken from these filters are then identified.

The work of the U.S. Public Health Service on taste- and odor-producing substances is being reported in a series of publications. Briefly, the taste and odor material is extracted from the carbon filters and divided into four groups: acids (organic), bases (amines and others), phenols, and neutral groups. This work has demonstrated that there are substances with fairly low taste and odor thresholds in all groups. The conclusion is that organic chemicals other than phenols are more responsible than phenols for the production of tastes and odors in some water supplies. Some of the nonphenols give phenolic tastes, and some of these chemicals apparently are not removed by chlorination. Hence, the development of limits on phenols and requirements for treating phenols to meet those limits will not necessarily assure taste-free water.

Future Objectives

Once the commission has established the water quality objective—the level below which, with present knowledge, there is no justification for requiring treatment—the commission will hold public hearings involving interstate streams or portions thereof for which the requirements are to be made binding. At the public hearing, the uses of the river, whether for industrial or domestic water supplies, fish life, or agricultural purposes, will be evaluated. Decisions will have to be made at that time on the degree of treatment required to protect the established water uses.

It is not meant to imply that nothing has yet been done to diminish the phenols discharged to the streams and to protect public water supplies. As an agency of the eight states in the Ohio Basin Compact, the commission's purpose is to coordinate a plan for stream pollution control within the

compact states. The data developed in establishing its recommendations will be of assistance to all regulatory agencies. Although no phenol limit has been set by the commission, progress is being made in the reduction of phenol compounds. For example, one major company has taken steps toward constructing a plant that will reduce by 98 per cent one of the largest phenol loads in the Ohio Basin. Both the state agencies and the steel industry are advancing individual programs in a number of other instances.

Not until the scope of the problem is known can intelligent control measures be adopted. Unless the waste is minimized before the treatment plant is constructed, money is wasted. And unless the treatment plant constructed will do what is expected of it, more money is wasted and the pollution abatement program receives a setback.

The magnitude of the job of defining the pollution problem with respect to taste- and odor-producing substances necessarily means that water works operators will have to handle taste and odor problems for some time to come. With industry continually making new products and causing new wastes, there are possibilities of other taste and odor problems in water works operation.

Fact finding and deliberation are necessary in developing a phenol water quality objective. The compact was designed by men who recognized that the real solution to pollution abatement rests on the realization of those who use the streams that there is a mutual need for clean waters. Proper development of a strong economy in the Ohio Basin demands it.

The cost of waste treatment eventually is passed on to the taxpayer, the consumer of the manufactured articles. So also is the cost of treating water for potable or industrial uses. Expense to the taxpayer can be minimized if the need for treatment is defined and treatment facilities are then constructed to meet that need.

Method for Predicting Michigan-Huron Lake Level Fluctuations

By Donald M. Pierce and John E. Vogt

A paper presented on May 13, 1953, at the Annual Conference, Grand Rapids, Mich., by Donald M. Pierce, San. Engr., and John E. Vogt, San. Engr., both of Div. of Eng., State Dept. of Health, Lansing, Mich.

COMPLETE records of levels of the Great Lakes extend back to 1860, and approximate records can be carried back to 1835. These records show that the levels fluctuate from year to year and from month to month during each year. In addition, the stages at specific places on the lakes vary from day to day and even from hour to hour, owing to the tilting of the lake surfaces. This phenomenon results from several causes, chiefly wind and differential barometric pressures. The annual and seasonal fluctuations amount to several feet, and the daily and hourly stage variations range from a few inches to many feet, according to the lake and place involved. Lake Erie has shown the greatest fluctuations due to wind, a gale in 1889 producing a difference in level of 15.3 ft between the two ends of the lake. It is not uncommon for differences of 12 ft to occur.

Extremes in lake levels cause serious distress in many ways. High levels flood beaches and permit erosion, thereby undermining cottages, roads, and other structures. Navigation interests are affected by difficulties in docking and loading of boats and damage to dock facilities. High levels in the lakes also cause the water in their tributaries to back up, thus aggravating floods and interfering with land drainage and the proper functioning of sanitary sewers.

On the other hand, low levels also affect shipping interests by reducing the cargoes which can be carried by lake freighters. In addition, unsightly flats are uncovered; waterfowl nesting grounds are decreased; boathouses and docks may be left high and dry, necessitating expensive harbor improvements; and water supply intakes may be exposed.

Physical Characteristics of Lake System

For a better understanding of the magnitude of the problem, some physical features of the Great Lakes system will be presented. Much of the information is taken from an excellent report by the U.S. Lake Survey (*1*).

The overall system, including the St. Lawrence River, extends a distance of approximately 2,000 miles, from the Gulf of St. Lawrence to the headwaters of the St. Louis River in northern Minnesota. The drainage area is approximately 300,000 sq miles, nearly one-third of which, 95,000 sq miles, is water. This high proportion of water surface causes differences in total annual rainfall and evaporation to be-

come uncommonly large factors in the water yield. The average volume of flow at Ogdensburg, N.Y., from Lake Ontario—which includes the entire discharge from the Great Lakes into the St. Lawrence, less diversions—is 230,000 cfs.

The connection between Lake Michigan and Lake Huron through the Straits of Mackinac is so broad and deep that there is no flow between the two lakes and they are, in effect, one body of water, usually referred to hydraulically as Lake Michigan-Huron. The surfaces of the two lakes are at the same elevation, and their total drainage area is approximately 142,000 sq miles, of which approximately one-third is water.

The Lake Michigan-Huron outflow is from the southern end of Lake Huron through the St. Clair River, Lake St. Clair, and the Detroit River to Lake Erie. This distance is approximately 84 miles, with a fall of approximately 8 ft in water surface. There is no definite control section which determines the outflow from Lake Huron. The entire system is the control, and the flow is a function of the elevations of Lake Michigan-Huron and Lake Erie. Since 1900 the average flow in the river system has been 175,100 cfs. Together with the average diversion of 6,300 cfs through the Chicago Sanitary Canal during the same period, this represents a combined average outflow of 181,400 cfs from Lake Michigan-Huron. Of this amount, 73,200 cfs is contributed by Lake Superior, with the Lake Michigan-Huron drainage basin supplying the remaining 108,200 cfs.

Changes or fluctuations in lake levels are due to a variety of forces, which may be generally classified as natural and artificial. Fluctuations due to natural forces include those resulting from variations in rainfall and evaporation, wind action, barometric pressure, ice obstruction of outlets, seiches, tides, and tilting of the land surface. Fluctuations due to artificial forces include diversions, regulation of inflow and outflow, channel improvements, and deforestation.

Natural Forces

The natural forces may be conveniently classified according to their duration as long range, seasonal, and transient. Long-range fluctuations are due principally to variations in rainfall and evaporation and to tilting of the land surface. Rain falling on lake surfaces has the direct effect of raising the levels by the number of inches of rainfall. The effect on lake levels of rain falling on the land surfaces of the drainage basins is variable, however, because the amounts ultimately reaching the lakes as runoff are influenced by many factors. Evaporation from the lake surfaces tends to lower the levels by the number of inches of the evaporation. To date no method has been devised to measure evaporation on an open lake. Tilting of the land surface has had a comparatively slight effect on Lake Michigan-Huron, although the levels of most of the Great Lakes have been slowly rising because of the subsidence of the coasts with respect to the lake outlets.

The pattern of the seasonal variation which usually prevails varies between high levels in summer and early fall and low levels in late winter. The natural forces of rainfall and evaporation, previously mentioned as affecting long-range fluctuations, also affect seasonal fluctuations. To these may be added ice obstructions in the outflowing streams.

Apart from the long-range and seasonal variations in lake levels, which involve the actual quantity of water present, marked variations of shorter duration may occur at specific locations as the result of wind and differences in barometric pressure. These transient fluctuations are present on all the lakes but occur most frequently and last longest on Lake Erie. There have been times when a strong easterly wind has driven the water into the west end of the lake and the Detroit River has actually reversed its flow. In Lake Michigan-Huron, the fluctuations are smaller and less frequent, but large changes of level due to wind action do occur, the difference in level amounting to 2 ft or more. The influence of barometric pressure on fluctuations is not so great as that of wind but is still appreciable. Very short-lived variations of several feet in lake level, causing phenomena which superficially resemble tidal waves, have been measured.

Two other natural forces of a transient nature which may affect lake levels at specific locations are seiches and tides. Only two true seiches have been demonstrated on the Great Lakes, both existing on Lake Superior. They are purely local in character. According to Kirshner (*2*), they occur in Marquette, Mich., and in the Duluth, Minn., and Superior, Wis., harbors. Tides do exist on the Great Lakes and were studied many years ago. The investigations disclosed, however, that their effect on lake levels is less than 2 in. (*3*).

Artificial Forces

The artificial forces influencing lake level fluctuations include diversions, channel improvements, deforestation, and regulation of inflow and outflow.

The only diversions into the Great Lakes drainage basin are those from the Hudson Bay drainage basin. The Long Lake Project, begun in 1937, at present adds an average of 1,400 cfs. A second diversion, known as the Ogoki Project, started in 1943, now averages 3,600 cfs. Both of these diversions are into Lake Superior. When their ultimate effect is attained, these diversions will raise the levels in Lake Michigan-Huron approximately 4 in.

The most important permanent diversion from Lake Michigan-Huron is that by the Chicago Sanitary Dist. Water taken from Lake Michigan flows through the Chicago Drainage Canal and the Illinois River into the Mississippi River. This diversion began in January 1900 and increased gradually to 9,000 cfs. In 1930 the U.S. Supreme Court ordered that the diversion be decreased to 1,500 cfs by Dec. 31, 1938. Since 1939, therefore, the diversion has averaged 1,500 cfs plus approximately 1,600 cfs for domestic pumpage. As the amount taken for the public water supply of Chicago is not returned to the lake, this is a permanent diversion. The 3,100-cfs diversion at Chicago has lowered the level of Lake Michigan-Huron on the order of 3 in.

The Welland Canal, with its 25-ft depth and eight locks, crosses the Niagara Peninsula and forms a navigable waterway around Niagara Falls, connecting Lake Erie and Ontario. The diversion through this canal is 5,900 cfs at present. Ultimately the effect of this diversion on Lake Michigan-Huron will be approximately 1 in.

Certain channel improvements in the St. Clair and Detroit rivers may be considered an artificial force which influenced the level of Lake Michigan-

Huron in the period 1860–1900. During that time shoals in both rivers were dredged or removed and the St. Clair Flats Canal was deepened to establish a channel 21 ft deep. Whether the channel dredging and other improvements in these rivers affected their discharge capacities, thereby lowering the level of Lake Michigan-Huron, is a matter of opinion. Freeman (*4*) quotes a number of reputable engineers to the effect that the channel improvements were not significant and concludes: "It is the opinion of the writer of this report that this lowering of Lake Huron is more apparent than real. . . ." Horton (*3*), on the other hand, believes that uncompensated improvements of these rivers have lowered the levels of Lake Michigan-Huron by an amount as great as 8–10 in.

The cutting of pine timber in the region tributary to Lake Superior and Lake Michigan-Huron since 1860 has tended to reduce the water losses from the drainage area through interception and transpiration—that is, interception of rainfall by the leaves and branches of the trees followed by direct evaporation without the water's reaching the ground, and transpiration by trees and plants through the openings in their leaves. At the same time the cutting of the timber tended to increase the water losses through direct evaporation from the soil. Farm crops, like forests, tend to reduce water losses resulting from soil surface evaporation but increase water losses by interception and transpiration. It seems quite evident, therefore, that the effects of these changes in vegetal cover tended to cancel each other out.

The only other artificial forces which may influence the levels of Lake Michigan-Huron are the inflow to it from Lake Superior and the outflow from it to Lake Erie. The flow coming to Lake Michigan-Huron from Lake Superior is completely controlled. Such control is effected by regulating works at St. Marys Falls, within limits established by international agreement between the United States and Canada. The International Joint Commission formed by the two countries agreed that the levels of Lake Superior would be held "as nearly as may be" between the elevations of 602.1 and 603.6 ft. The agreement further provided that, when the levels exceeded this range, outflows would be regulated so that ensuing levels would not exceed the maximums and minimums that would have prevailed on the lake under natural outflow conditions. Therefore, Lake Superior is being controlled essentially within the natural range of seasonal and long-time fluctuations, so that the control has no more than minor, temporary effects on the levels of Lake Michigan-Huron.

There is no manmade control regulating the outflow from Lake Michigan-Huron. Owing to backwater effects, however, the natural controlling factors operate in a somewhat complicated manner. Beginning at the Niagara River, the elevation of Lake Erie is controlled by the outflow from Lake Michigan-Huron (by shoals at the head of the Niagara River and, to a smaller extent, by the crest of the rapids at Niagara Falls). Lake Erie reacts through backwater on the lower Detroit River, which, in turn, operates through backwater on Lake St. Clair. The level of Lake Michigan-Huron is thus controlled jointly by the channel topography of the St. Clair River and by the level of Lake St. Clair.

Aggregate Effect

It has been shown that many and varied forces combine to affect the

levels of the Great Lakes. Some of these forces tend to counterbalance each other; others result in apparent cycles of extremely high and extremely low levels; and still others, of short duration, are superimposed on the general levels prevailing at the time. In Lake Michigan-Huron, the aggregate of the various forces produces fluctuations in the monthly average lake level within any one year on the order of 2 ft. For the 92 years of record the difference between minimum and maximum monthly mean elevations is slightly more than 6 ft.

Economic Consequences

Today thousands of property owners along the shores of the Great Lakes and their connecting rivers are watching with increasing alarm the slow, inexorable encroachment of these waters upon their property. For hundreds of miles along the fringes of Lakes Huron, Michigan, St. Clair, Erie, and Ontario and the St. Clair and Detroit rivers connecting Lakes St. Clair and Erie, property damage from the ravaging waters is steadily mounting with the seasonal rise of the Great Lakes system.

By midsummer of 1951, owners of homes and cottages along these shorelines had begun to feel some apprehension over the rising lake levels. Many had seen the beaches in front of their homes slowly diminish and, for the first time within their short experience of lakeside residence, found that water had begun to creep across their land. Similarly, municipally owned facilities, such as sewer lines, sewage pumping stations, and public beaches, were inundated and otherwise impaired for the first time since their construction or establishment. At one location, an industrial-waste pipeline many miles long was washed out of position and its usefulness almost totally destroyed. This experience was shared to some extent by homeowners, municipalities, and industries located along many connecting lakes and rivers whose elevations are closely affected by the levels of the Great Lakes. On the shores of one such lake, the authors observed several manholes of the main interception sewer under water and, not far away, saw a fishing-boat dock covered with approximately 2 ft of water.

Although the lake levels had exceeded these 1951 elevations several times prior to 1900 and as recently as 1929, only a few remembered the high waters of those periods. The majority of those now affected had built their cottages and homes, their public or industrial facilities, close to the shoreline during periods when the lake levels remained below the 1951 maximum. They clearly remembered the unusually low water levels of recent years, when their beaches had been abnormally exposed and enlarged. Now, suddenly and unexpectedly, the lakes had risen so high that dwellings and shoreline facilities were in imminent danger. Most of those affected or threatened could have avoided this danger and problem had they checked the previous lake level records. But the desire to live close by the shoreline has been so impelling throughout the ages that it has dulled man's memory of past disasters and his otherwise natural instinct for safeguarding his home and his property.

The concern felt during the summer of 1951 by those least protected from the effects of high waters of the Great Lakes grew into a feeling of general alarm during the autumn, when the lake levels continued to rise rather than fall in the usual seasonal pattern.

By late autumn scores of municipalities had begun to seek relief, assistance, and advice from government agencies. Stories and articles frequently appeared in newspapers and magazines describing damage already incurred and conjecturing about the probable damage to be experienced in 1952. Some of the factual information previously outlined in this article began to reach the public, whose interest and concern grew as the story was unfolded.

In studying the fluctuations of levels in the Michigan-Huron system, the authors, aside from a natural curiosity and concern, were prompted by official interest, as staff engineers of the Michigan Dept. of Health, in the effect of abnormally high waters on the public health. This interest was sharpened by the impression, since confirmed, that no sound basis for predicting lake level elevations was then known to the U.S. Lake Survey of the Corps of Engineers, whose responsibility it is to collect and report data on the levels of all of the Great Lakes. It was known, however, that much study had been devoted to attempts to find some practicable method of prediction.

In spite of indications that the lake level data are not adaptable to forecasting future elevations, it was the purpose of the authors to devote sufficient study to the data available from the U.S. Lake Survey and other sources to become familiar with the nature and magnitude of the fluctuations and to apply certain statistical tools with the hope that some relationships usable for prediction might be found. The remainder of this paper is devoted to a description of the adaptation of accepted statistical methods to this problem. Methods are developed by which predictions may be made of the monthly mean high elevation of the Michigan-Huron system for the year several months before its occurrence.

Statistical Analysis

It has been observed that many complex forces, some natural and others resulting from the works of man, influence the levels of the Great Lakes. Although the magnitude and range of some of these forces are known or can be reasonably estimated, the effects of other forces are not so readily computed. Indeed, experts disagree rather widely on the effect of evaporation from the lake surface under varying conditions of wind action, temperature, and humidity. The experts further disagree on the effect of several physical changes in inlet and outlet controls which have been constructed during the past 50 years. The opinion is expressed by some who have made long and exhaustive studies of these forces that all the forces induced by manmade controls have tended to balance each other out. Lacking information to the contrary, it was decided to confine the present studies to patterns of variation in lake levels over the total period of record, 1860–1950, inclusive, without regard to the forces which may be responsible.

Data for these studies were obtained from the lake level charts prepared by the U.S. Lake Survey (*1*). Only the Michigan-Huron system was considered. The mean elevation of the total lake surface for each month was determined from recording gages strategically located at stations along the shores of the two lakes. Such elevations are thus adjusted for the effects

TABLE 1—*Annual High and Low Lake Levels and Differences, Based on Monthly Means*

Year	High		Low		Diff. *ft*	Year	High		Low		Diff. *ft*
	El*—*ft*	Month	El*—*ft*	Month			El*—*ft*	Month	El*—*ft*	Month	
1860	6.3	July	5.1	Dec.	1.2	1906	4.4	July	3.5	Jan.	0.9
1861	6.5	Aug.	5.0	Jan.	1.5	1907	4.6	July	3.6	Dec.	1.0
1862	6.2	June	5.3	Feb.	0.9	1908	4.7	July	3.2	Dec.	1.5
1863	5.6	June	5.1	Dec.	0.5	1909	4.1	July	2.9	Jan.	1.2
1864	5.8	Aug.	3.9	Dec.	1.9	1910	3.5	June	2.5	Dec.	1.0
1865	5.1	July	3.7	Jan.	1.4	1911	3.0	June	2.3	Jan., Apr.	0.7
1866	4.7	Aug.	3.4	Feb.	1.3	1912	3.7	Sept.	2.2	Feb., Mar.	1.5
1867	5.2	July	3.8	Dec.	1.4	1913	4.3	July	3.0	Feb.	1.3
1868	4.7	July	3.5	Dec.	1.2	1914	3.7	July	2.7	Dec.	1.0
1869	5.1	Aug.	3.2	Mar.	1.9	1915	3.0	Sept.	2.4	Dec.	0.6
1870	5.7	Sept.	4.2	Jan.	1.5	1916	4.1	July	2.3	Jan.	1.8
1871	5.8	July	3.6	Dec.	2.2	1917	4.9	July	3.4	Feb.	1.5
1872	4.5	July	3.3	Mar.	1.2	1918	4.9	June	3.7	Jan.	1.2
1873	5.2	Aug.	3.3	Jan.	1.9	1919	4.3	June	3.2	Dec.	1.1
1874	5.3	June	4.2	Nov.	1.1	1920	4.0	July	2.9	Feb.	1.1
1875	5.1	Sept.	4.6	Feb.	1.1	1921	3.4	May	2.5	Dec.	0.9
1876	6.6	July	4.7	Feb.	1.9	1922	3.6	July	2.2	Feb., Dec.	1.4
1877	5.7	July	5.1	Dec.	0.6	1923	2.8	June	1.8	Feb., Dec.	1.0
1878	5.5	July	4.8	Dec.	0.7	1924	2.6	Aug.	1.4	Dec.	1.2
1879	4.5	July	3.9	Dec.	0.6	1925	1.4	July	0.6	Dec.	0.8
1880	5.1	July	3.9	Mar.	1.2	1926	1.5	July	0.3	Feb.	1.2
1881	5.2	Nov.	4.1	Jan.	1.1	1927	2.6	July	1.2	Jan.	1.4
1882	5.6	Aug.	4.7	Feb.	0.9	1928	3.6	Nov., Dec.	1.8	Feb.	1.8
1883	6.3	Aug.	4.6	Feb.	1.7	1929	5.3	July	3.5	Feb.	1.8
1884	6.1	July	5.2	Dec.	0.9	1930	4.2	July	2.5	Dec.	1.7
1885	6.3	Aug.	5.3	Feb.	1.0	1931	2.1	July	1.2	Dec.	0.9
1886	6.7	June	5.4	Dec.	1.3	1932	1.6	July	0.7	Dec.	0.9
1887	5.9	July	4.3	Dec.	1.6	1933	1.7	July	0.5	Jan., Mar.	1.2
1888	5.3	Aug.	4.2	Feb.	1.1	1934	1.0	July	0.4	Mar.	0.6
1889	4.7	July	3.7	Dec.	1.0	1935	1.6	July	0.6	Jan.	1.0
1890	4.6	July	3.6	Mar.	1.0	1936	1.7	June	0.8	Dec.	0.9
1891	3.9	May	2.8	Dec.	1.1	1937	1.6	July	0.8	Jan.	0.8
1892	4.0	Aug.	2.8	Feb.	1.2	1938	2.6	Aug.	0.6	Jan.	2.0
1893	4.3	July	2.7	Feb.	1.6	1939	2.9	Aug.	1.7	Feb.	1.2
1894	4.4	July	3.2	Jan.	1.2	1940	2.3	Sept.	1.5	Mar.	0.8
1895	3.2	June	2.0	Dec.	1.2	1941	2.0	June, Nov.	1.7	Mar.	0.3
1896	3.0	Sept.	2.1	Jan.	0.9	1942	3.1	July	1.9	Jan.	1.2
1897	3.8	Aug.	2.4	Feb.	1.4	1943	4.5	Aug.	2.3	Jan.	1.2
1898	3.8	July	2.7	Jan.	1.1	1944	3.8	July	3.0	Dec.	0.8
1899	4.1	July	2.6	Feb.	1.5	1945	4.0	July	2.5	Feb.	1.5
1900	3.7	Sept.	2.8	Jan.	0.9	1946	4.0	July	2.6	Dec.	1.4
1901	4.1	Aug.	3.1	Mar.	1.0	1947	4.1	July, Aug.	2.4	Jan., Mar.	1.7
1902	3.8	Aug.	2.7	Mar.	1.1	1948	3.8	May, July	2.3	Dec.	1.5
1903	3.8	Oct.	2.7	Jan.	1.1	1949	2.7	July	1.2	Dec.	1.5
1904	4.5	July	2.7	Jan.	1.8	1950	3.0	Aug.	1.3	Jan.	1.7
1905	4.6	July	3.3	Mar.	1.3						

* Datum = 577.0 ft.

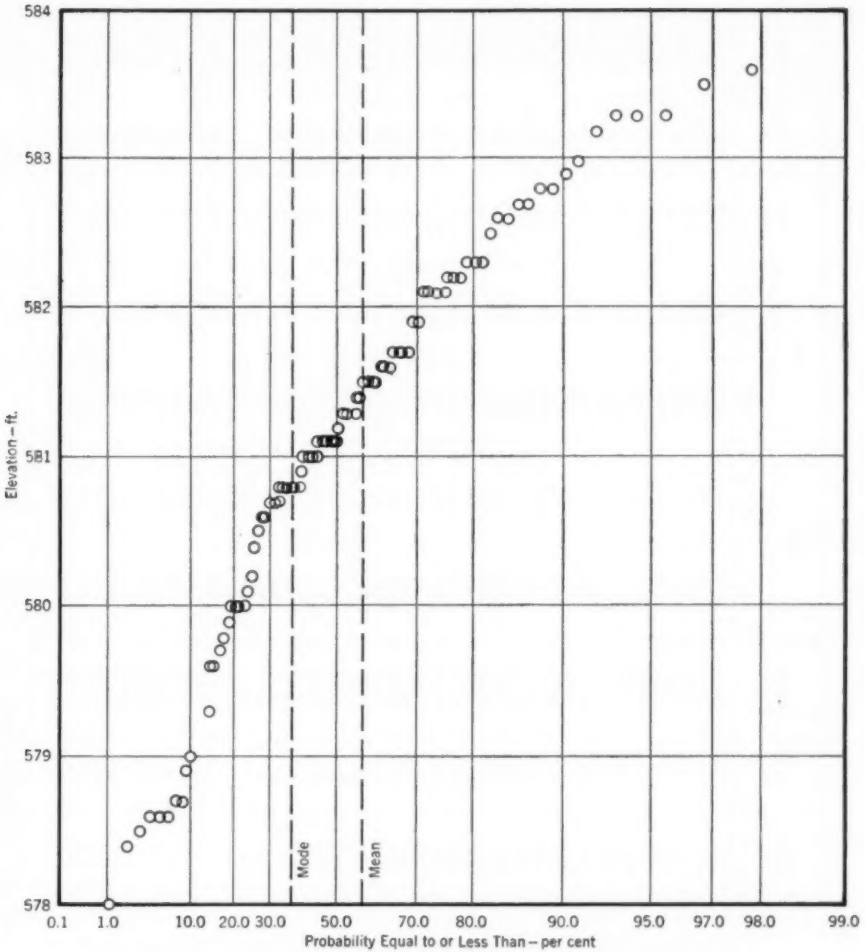

Fig. 1. Annual Maximum Monthly Mean Elevations, 1860–1950

As a reasonably good straight-line relationship is not presented in this plotting on special coordinate paper, it appears that the distribution is not one of extreme values.

of wind, seiches, and barometric pressure variations, which tend to distort the true mean elevation of the total lake surface.

The highest and lowest monthly mean elevations for each year are shown in Table 1. These data have been rearranged in Table 2 in order of magnitude for high levels, low levels, and differences, to determine by graphical analyses:

1. Whether the distribution of each set of values (high, low, and differences) follows the pattern of extreme values, such as for floods and droughts in river systems, or whether such dis-

TABLE 2—*Data in Table 1 Rearranged* for Normal-Probability Plotting*

High		Low		Diff.	No.	$\frac{100m}{n+1}$ ‡	High		Low		Diff.	No.	$\frac{100m}{n+1}$ ‡
Year	El†—*ft*	Year	El†—*ft*	*ft*	*m*		Year	El†—*ft*	Year	El†—*ft*	*ft*	*m*	
1934	1.0	1886	5.4	0.5	1	1.09	1930	4.2	1891	2.8	1.2	47	51.09
1925	1.4	1862	5.3	0.6	2	2.17	1893	4.3	1900	2.8	1.2	48	52.17
1926	1.5	1885	5.3	0.6	3	3.26	1913	4.3	1893	2.7	1.2	49	53.26
1932	1.6	1884	5.2	0.6	4	4.35	1919	4.3	1898	2.7	1.2	50	54.35
1935	1.6	1860	5.1	0.6	5	5.43	1894	4.4	1902	2.7	1.2	51	55.43
1937	1.6	1863	5.1	0.7	6	6.52	1906	4.4	1903	2.7	1.2	52	56.52
1936	1.7	1877	5.1	0.7	7	7.61	1872	4.5	1904	2.7	1.2	53	57.61
1933	1.7	1861	5.0	0.8	8	8.70	1879	4.5	1914	2.7	1.2	54	58.70
1941	2.0	1871	4.8	0.8	9	9.78	1904	4.5	1899	2.6	1.3	55	59.78
1931	2.1	1876	4.7	0.8	10	10.87	1943	4.5	1946	2.6	1.3	56	60.87
1940	2.3	1882	4.7	0.8	11	11.96	1890	4.6	1910	2.5	1.3	57	61.96
1924	2.6	1883	4.6	0.9	12	13.04	1905	4.6	1921	2.5	1.3	58	63.04
1927	2.6	1887	4.3	0.9	13	14.13	1907	4.6	1930	2.5	1.4	59	64.13
1938	2.6	1870	4.2	0.9	14	15.22	1866	4.7	1945	2.5	1.4	60	65.22
1949	2.7	1874	4.2	0.9	15	16.30	1868	4.7	1897	2.4	1.4	61	66.30
1923	2.8	1888	4.2	0.9	16	17.39	1889	4.7	1915	2.4	1.4	62	67.39
1939	2.9	1881	4.1	0.9	17	18.48	1908	4.7	1947	2.4	1.4	63	68.48
1896	3.0	1875	4.0	0.9	18	19.57	1917	4.9	1911	2.3	1.4	64	69.56
1915	3.0	1864	3.9	0.9	19	20.65	1918	4.9	1916	2.3	1.5	65	70.65
1911	3.0	1879	3.9	0.9	20	21.74	1865	5.1	1943	2.3	1.5	66	71.74
1950	3.0	1880	3.9	0.9	21	22.83	1869	5.1	1948	2.3	1.5	67	72.83
1942	3.1	1867	3.8	1.0	22	23.91	1875	5.1	1912	2.2	1.5	68	73.81
1895	3.2	1918	3.7	1.0	23	25.00	1880	5.1	1922	2.2	1.5	69	75.00
1921	3.4	1865	3.7	1.0	24	26.09	1867	5.2	1896	2.1	1.5	70	76.09
1910	3.5	1889	3.7	1.0	25	27.17	1873	5.2	1895	2.0	1.5	71	77.17
1922	3.6	1871	3.6	1.0	26	28.26	1881	5.2	1942	1.9	1.5	72	78.26
1928	3.6	1890	3.6	1.0	27	29.35	1874	5.3	1923	1.8	1.6	73	79.35
1900	3.7	1907	3.6	1.0	28	30.43	1929	5.3	1928	1.8	1.6	74	80.43
1912	3.7	1868	3.5	1.0	29	31.52	1888	5.3	1939	1.7	1.7	75	81.52
1914	3.7	1906	3.5	1.0	30	32.61	1878	5.5	1941	1.7	1.7	76	82.61
1897	3.8	1929	3.5	1.1	31	33.70	1863	5.6	1940	1.5	1.7	77	83.70
1898	3.8	1866	3.4	1.1	32	34.78	1882	5.6	1924	1.4	1.7	78	84.78
1902	3.8	1917	3.4	1.1	33	35.87	1870	5.7	1950	1.3	1.7	79	85.87
1903	3.8	1872	3.3	1.1	34	36.96	1877	5.7	1927	1.2	1.7	80	86.96
1944	3.8	1873	3.3	1.1	35	38.04	1864	5.8	1931	1.2	1.8	81	88.04
1948	3.8	1905	3.3	1.1	36	39.13	1871	5.8	1949	1.2	1.8	82	89.13
1891	3.9	1869	3.2	1.1	37	40.22	1887	5.9	1936	0.8	1.8	83	90.22
1892	4.0	1894	3.2	1.1	38	41.31	1884	6.1	1937	0.8	1.8	84	91.30
1920	4.0	1908	3.2	1.1	39	42.39	1862	6.2	1932	0.7	1.9	85	92.39
1945	4.0	1919	3.2	1.1	40	43.48	1860	6.3	1925	0.6	1.9	86	93.48
1946	4.0	1901	3.1	1.2	41	44.56	1883	6.3	1935	0.6	1.9	87	94.56
1899	4.1	1913	3.0	1.2	42	45.65	1885	6.3	1938	0.6	1.9	88	95.65
1901	4.1	1944	3.0	1.2	43	46.74	1861	6.5	1933	0.5	2.0	89	96.74
1909	4.1	1909	2.9	1.2	44	47.83	1876	6.6	1934	0.4	2.2	90	97.83
1916	4.1	1920	2.9	1.2	45	48.91	1886	6.7	1926	0.3	2.2	91	98.91
1947	4.1	1892	2.8	1.2	46	50.00							

* In order of magnitude. † Datum = 577.0 ft. ‡ Plotting position.

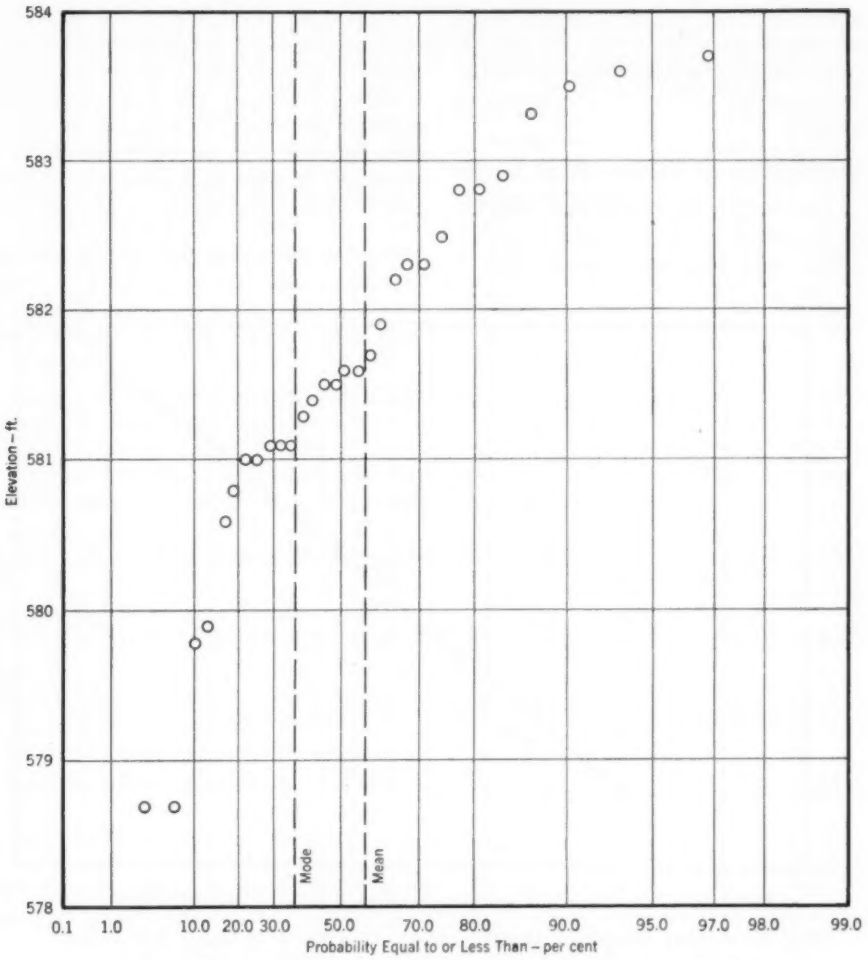

Fig. 2. Three-Year Maximum Monthly Mean Elevations, 1860–1950

As in Fig. 1, no straight-line relationship is evident, indicating that the distribution is not one of extreme values.

tributions are otherwise skewed or are normal.

2. The mean elevation of the annual high monthly mean elevations and of the annual low monthly mean elevations, and the mean difference thereof.

3. The probability of exceeding any given elevation, for both the high and low points of the yearly cycle.

4. The correlation of annual low monthly mean elevations with annual high monthly mean elevations.

5. The future high monthly mean elevation, on the basis of the preceding low monthly mean elevation.

Additional studies were made to develop a relationship between the annual mean lake level elevation (deter-

mined by averaging the monthly mean elevations for each year) and the 5-year rainfall preceding such elevation. The data for this study are shown in Table 4.

Distribution of Values—High Levels

The data for the annual high monthly mean elevations for 91 years (1860–1950) were transferred from Table 1 to Table 2, in which: [1] all values were arranged in order of ascending magnitude, referred to a datum of 577.0 ft; [2] each value was assigned a serial number, m, from 1 to 91; [3] the plotting position for each number was determined by dividing the serial number, m, by the total number, $n = 91$, plus 1, or 92, the quotient being multiplied by 100.

Data from Table 2 were first plotted on Gumbel paper for extreme values, in order to determine whether the distribution of values was skewed to the right of the mean, as normally occurs in connection with such phenomena as flood and drought flow in rivers. Figure 1 shows the elevations plotted as ordinates and values for $\frac{100\ m}{n+1}$ (percentage probability) plotted as abscissas. The fact that a reasonably good straight-line relationship did not develop indicated that the distribution was not one of extreme values. A further study of extreme values was made by plotting 3-year maximum monthly mean elevations on Gumbel paper. Data for this analysis are arranged in Table 3 and plotted in Fig. 2. The

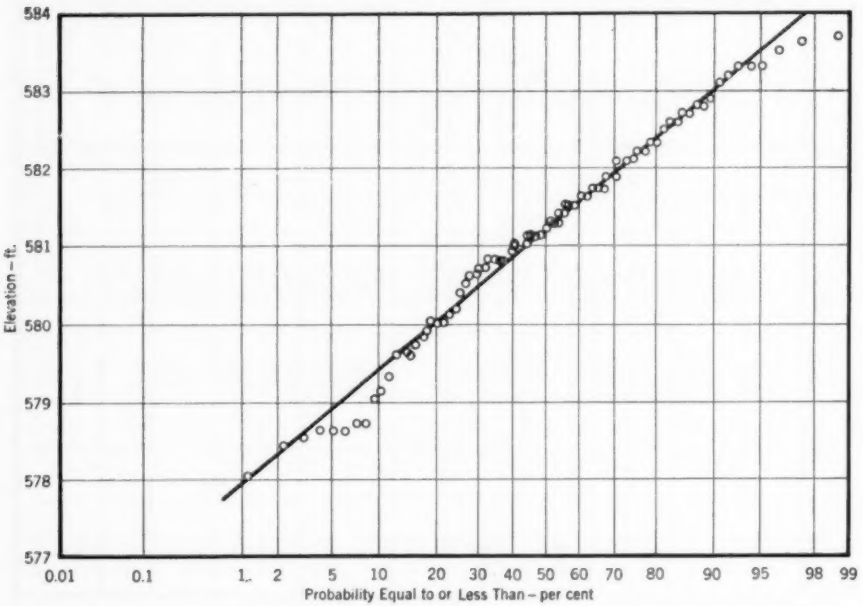

Fig. 3. Annual Maximum Monthly Mean Elevations (Normal Probability)

The data used in Fig. 1 are here plotted on normal-probability paper. The good fit shown by the straight line indicates a normal distribution.

relationship was not improved. It was therefore decided to plot the data from Table 2 on normal-probability paper.

The normal-probability plotting is shown in Fig. 3. A straight line drawn through the plotted points gives a very good fit, which is interpreted to indicate that the distribution of annual high monthly mean elevations for the 91 years is normal and is derived from the same universe, with balanced distribution around a mean, centering value.

The mean of the annual high monthly mean elevations, or the centering value for all yearly high monthly mean elevations, is 581.2. This is the most probable value for the high monthly mean. It may also be observed from Fig. 3 that 95 per cent of the time such a mean elevation would not be expected to exceed 583.5. In other words, this elevation should not be exceeded more than four or five times in 91 years. It is interesting to note that actually el 583.5 was exceeded twice during that period and equaled once. Similarly, el 583.0 should not be exceeded more than nine times (10 per cent) in 91 years. It was actually exceeded eight times. It is worth mentioning that these high values nearly always occur in the months of June, July, or August.

Distribution of Values—Low Levels

Data for annual low monthly mean elevations were treated in the same way as the high values discussed in the preceding section. They are arranged by order of magnitude, serial number, and plotting position in Table 2. A straight line shows an excellent fit for these points as plotted in Fig. 4, with all but a very few of the values clustering very closely about it. As with the high values, the distribution is shown to be normal for random sampling from the same universe.

TABLE 3

Three-Year Maximum Lake Elevations, Based on Monthly Means

3-yr Max. El*—*ft*		No. m	$\frac{100m}{n+1}$ †
Chronological	In Order of Magnitude		
6.5	1.7	1	3.23
5.8	1.7	2	6.45
5.2	2.8	3	9.68
5.8	2.9	4	12.90
5.3	3.6	5	16.13
6.6	3.8	6	19.35
5.5	4.0	7	22.58
6.3	4.0	8	25.81
6.7	4.1	9	29.03
5.9	4.1	10	32.26
4.6	4.1	11	35.48
4.4	4.3	12	38.71
3.8	4.4	13	41.94
4.1	4.5	14	45.16
4.5	4.5	15	48.39
4.6	4.6	16	51.61
4.7	4.6	17	54.84
4.3	4.7	18	58.06
4.1	4.9	19	61.29
4.9	5.2	20	64.52
4.0	5.3	21	67.74
2.8	5.3	22	70.97
3.6	5.5	23	74.19
5.3	5.8	24	77.42
1.7	5.8	25	80.65
1.7	5.9	26	83.87
2.9	6.3	27	87.10
4.5	6.5	28	90.32
4.0	6.6	29	93.55
4.1	6.7	30	96.77

* Datum = 577.0 ft.
† Plotting position.

It may be noted that 50 per cent of the time the yearly low monthly mean elevation will be equal to or greater than 579.9. There is a 95 per cent probability that such an elevation will not be less than 577.7. Four or five values should lie below this elevation,

and six of the 91 actually do. Ten per cent, or nine values, should exceed 581.6. Eleven do. This is rather substantial proof that a normal-probability distribution exists.

Distribution of Differences

The differences between the high mean monthly elevation for each year and the corresponding low mean monthly elevation are shown in Table 2, as are the serial numbers and plotting positions. The methods of plotting these values on normal probability paper (Fig. 5) are similar to those discussed in the two preceding sections.

Again a normal distribution is evidenced by the close fit of the straight line through the plotted points. There is a 50 per cent chance that the difference between the low and high mean monthly elevation in any one year will be equal to or less than 1.25 ft. There is a 90 per cent probability that this difference will be 1.75 ft or less, a 95 per cent probability that it will be 1.90 ft or less, and a 97.5 per cent probability that it will be 2.0 ft or less. These probabilities check very closely with observations for the 91 years of record.

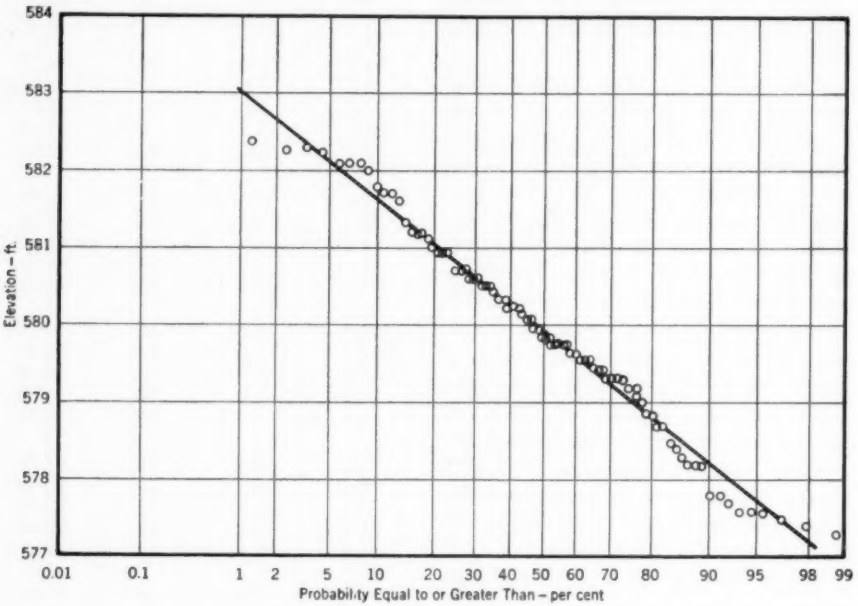

Fig. 4. Annual Minimum Monthly Mean Elevations, 1860–1950

Like the maximum levels, the minimum levels appear to be normally distributed.

Correlation of Highs and Lows

The method of least squares was employed to correlate the annual low monthly mean elevation with the annual high monthly mean elevation of

the same year. The procedure was to: [1] plot the high against the corresponding low values for each year (Table 1) on Cartesian coordinate paper, with high as the ordinate and low as the abscissa; [2] construct a straight line of best fit through all points by the method of least squares; and [3] calculate the standard error of the estimate and construct lines parallel with the line of best fit above and below it at a distance representing the desired confidence limits. Formulas and calculations are shown in the Appendix.

The coefficient of correlation is calculated as 0.956. By chance alone, this value would be only 0.315. This demonstrates a very high degree of correlation between the high and low monthly mean values.

The line of best fit represents the mean correlation or the 50 per cent probability of occurrence. To increase the probability to 95.5 per cent, two standard errors are employed, represented by lines *BB* and *CC* above and below the line of the mean in Fig. 6. The band *BB–CC* lies 0.80 ft on each

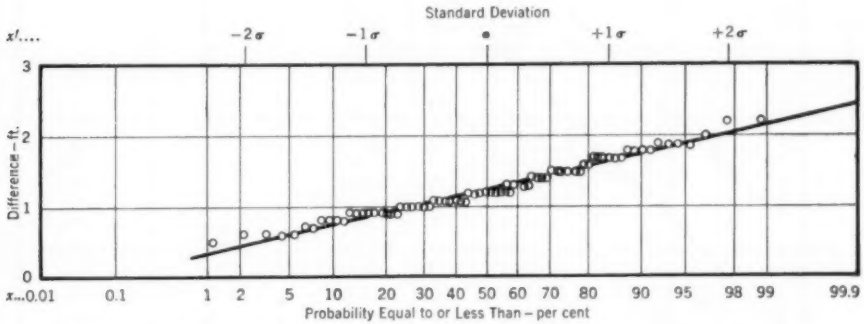

Fig. 5. Differences Between Maximum and Minimum Monthly Mean Elevations

There is a 50 per cent probability that the difference between the high and low levels in any given year will not exceed 1.25 ft.

The points for all elevations are plotted in Fig. 6. A line of best fit with y intercept at $C_0 = 1.22$ (that is, $577.0 + 1.22 = 578.22$) and a slope of 1.003 is shown as *AA*. It is interesting to note that, as the slope of the line is almost precisely 45 deg, all points on the line for the annual high mean monthly elevations are 1.22 ft higher than the corresponding low mean monthly elevation for that year. This method closely checks with Fig. 5, in which the mean difference was observed to be 1.25 ft..

side of the mean. This may be interpreted to indicate that there is a 95.5 per cent probability that the difference between the high and low monthly mean values for any given year will lie in the range of 1.22 ± 0.80 ft, or between 0.42 and 2.02 ft. Referring to Fig. 5 again, the 95.5 per cent certainty range would lie a distance of 47.75 per cent on each side of the mean, or from 2.25 per cent to 97.75 per cent (shown as -2 and $+2$ on the x′ axis). Values are read as 0.48 ft and 2.0 ft, respectively. It is evident that the two meth-

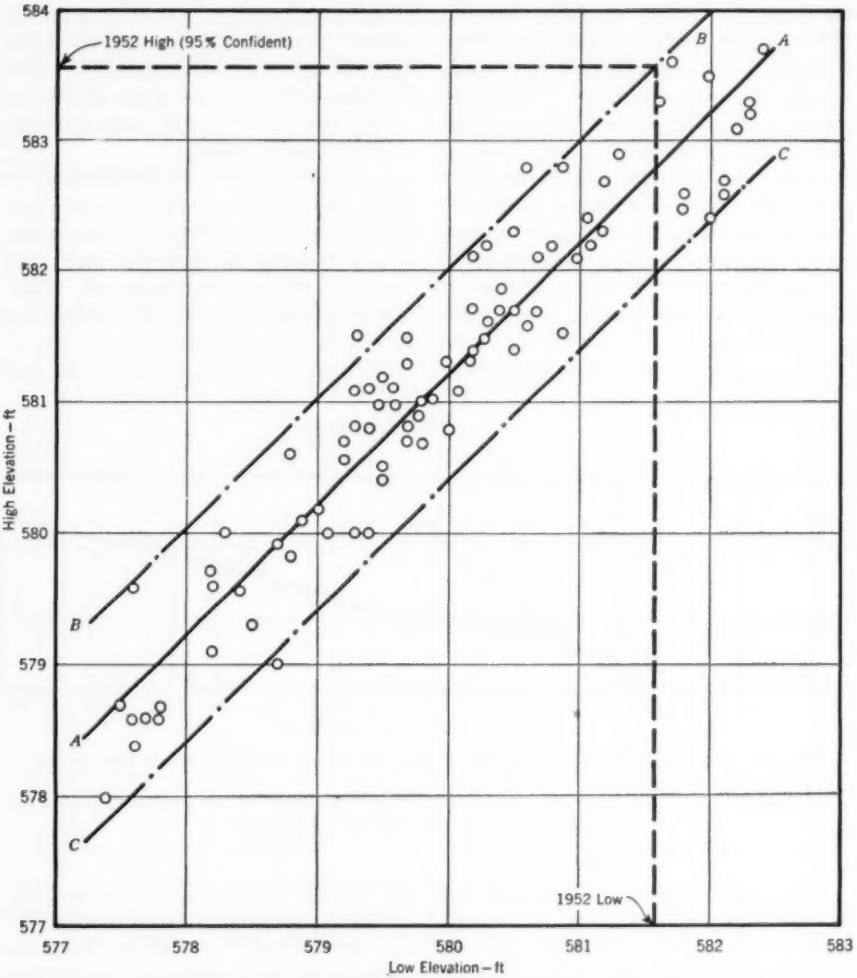

Fig. 6. Correlation Between High and Low Levels

Line AA *represents the mean correlation; the band formed by lines* BB *and* CC *represents 95.5 per cent probability. For example, with a low of 581.6 ft in 1952, it was 50 per cent probable that the high would be 582.8 ft and 95.5 per cent probable that the high would lie between 582.0 and 583.6 ft.*

ods produce identical results within the limits of plotting accuracy. It is demonstrated not only that there is a normal distribution of values for the 91 years but that there is also a very close correlation between high and low values, the range of which may be estimated within desired confidence limits.

In order to narrow the range around the mean difference within any desired

confidence limit, calculations were made for multiple correlation, using the high monthly mean elevation of a given year and the low monthly mean elevation of the succeeding year as a basis for predicting the succeeding annual high monthly mean elevation. For instance, if the annual high occurs in July, the succeeding annual low in January, and the following annual high in August, these three figures would be used to establish a correlation between the first two and the third. Calculations made on this basis indicate that the addition of the third variable does not alter the relationship obtained from single correlation.

Correlation of Rainfall and Levels

According to the literature, many unsuccessful attempts have been made to correlate rainfall with lake levels. The authors' examination of rainfall data for the Michigan-Huron watershed revealed that such data have not been integrated in terms of runoff from the area to the lake system. In 1925, however, Horton (*3*) reported a set

TABLE 4

Relationship Between Rainfall and Lake Levels

Year	5-yr Mean Annual Rainfall *in.*	Annual Mean Lake Level *ft*	Year	5-yr Mean Annual Rainfall *in.*	Annual Mean Lake Level *ft*
1875	31.4	581.64	1900	33.1	580.30
1876	32.7	582.67	1901	33.1	580.57
1877	34.1	582.39	1902	32.7	580.20
1878	35.1	582.13	1903	33.4	580.34
1879	36.7	581.26	1904	33.1	580.83
1880	37.4	581.41	1905	33.4	580.95
1881	37.7	581.81	1906	33.4	580.97
1882	38.4	582.15	1907	32.7	581.03
1883	38.7	582.44	1908	31.7	580.95
1884	39.1	582.64	1909	32.4	580.43
1885	38.4	582.80	1910	31.1	580.11
1886	37.7	583.01	1911	31.1	579.56
1887	36.4	582.36	1912	32.4	580.03
1888	34.7	581.73	1913	32.7	580.66
1889	33.4	581.22	1914	32.1	580.21
1890	33.1	581.05	1915	32.4	579.62
1891	32.4	580.48	1916	33.4	580.34
1892	33.1	580.31	1917	32.1	581.08
1893	34.1	580.50	1918	32.1	581.27
1894	34.1	580.70	1919	32.7	580.81
1895	32.7	579.84	1920	32.7	580.43
1896	32.7	579.53	1921	32.1	580.02
1897	32.4	580.14	1922	32.7	579.87
1898	31.7	580.28	1923	32.1	579.27
1899	31.7	580.30			

of 5-year average rainfall values for the period 1875–1923, representing composite values from selected rainfall gaging stations to which weights have been assigned for factors of drainage area, runoff characteristics, and other major considerations. As the precise methods for determining these modifying weights were not disclosed, the rainfall values are used without analysis by the present authors. These data

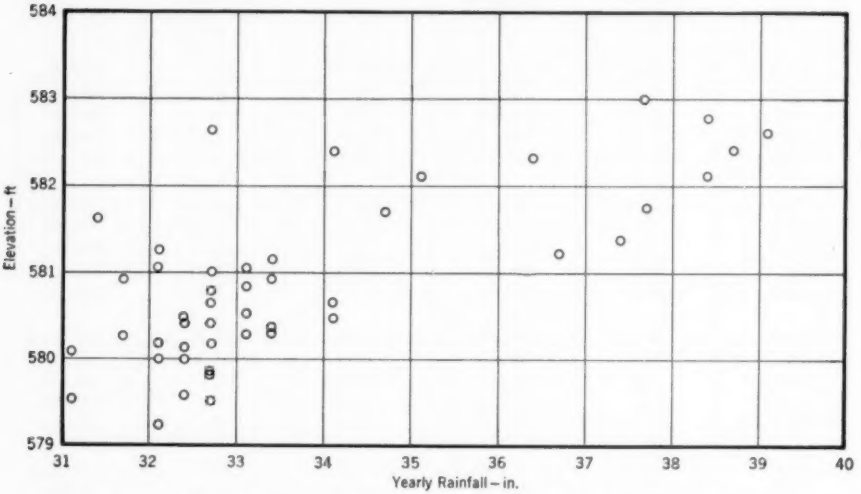

Fig. 7. Correlation Between Annual Mean Levels and 5-Year Mean Rainfall

The widely scattered distribution shows that no meaningful correlation is obtainable from these data.

are shown in Table 4. The annual mean levels listed in Table 4 are computed as the annual average of the monthly means.

In Fig. 7, the 5-year average rainfall is plotted against the annual mean lake level. It is evident from the widely scattered distribution of these values that correlation cannot be obtained within meaningful limits. This does not necessarily mean that a closer relationship does not exist, but rather that it has not been established on the basis of information available to the authors.

Conclusions

The results of these statistical studies indicate that, in spite of many conflicting forces varying greatly in magnitude and individual effect on the levels of the Michigan-Huron lake system, a rather close balance between monthly mean elevations is maintained. On the basis of 91 years of lake level elevation data, these studies indicate that:

1. There is a normal distribution of values of annual high monthly mean elevations, such as might normally be expected from random sampling of a single universe.

2. There is an equally normal distribution of annual low monthly mean

elevations and of differences in elevations between such high and low monthly mean values.

3. There is a 50 per cent chance that the difference between the lowest monthly mean elevation and the highest monthly mean elevation in any one year will not exceed 1.25 ft.

4. It is 95 per cent certain that this difference will not exceed 2.0 ft or be less than 0.4 ft.

5. There is a 50 per cent chance that the high monthly mean elevation for any given year will not exceed 581.2. There is 95 per cent certainty that this elevation will not exceed 583.5. The probability that el 585.0 will be exceeded by the high annual monthly mean is only 17 in 10,000.

6. There is a 50 per cent probability that the low monthly mean elevation occurring in any given year will not be less than 579.9. There is a 95 per cent probability that the elevation will not be less than 577.7.

7. No correlation between rainfall and lake levels can be found from available data.

Predictions

The observations discussed in the previous sections provide a rational statistical basis for predicting the maximum monthly mean elevation of the Michigan-Huron system for any year, based upon the predictable increase in elevation above the observed minimum monthly mean elevation for that year. In 1952 this minimum mean elevation occurred in January and was 581.56 ft. Using the methods described, the authors predicted that the most probable maximum monthly mean elevation for that year would be 582.8, and they were 95 per cent confident the maximum monthly mean elevation would lie between 582.0 and 583.6. Reports of the U.S. Lake Survey show that the actual maximum monthly mean elevation was 582.7.

The minimum monthly mean for 1953 occurred in February and was 581.2 ft.* Applying the same methods of prediction, the most probable maximum monthly mean elevation for 1953 will be 582.45. It is 95 per cent certain that the monthly mean elevation for the maximum month will lie between 581.65 and 583.25.

Acknowledgment

The authors wish to express their appreciation to the staff of the Dept. of Public Health Statistics, School of Public Health, University of Michigan, Ann Arbor, Mich., for their valuable assistance and many helpful suggestions during the course of this research. The authors are particularly indebted to the following members of the department: C. J. Velz, Chairman; John J. Gannon, Asst. Prof.; and Fay M. Hemphill, Resident Lecturer.

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* The figure given represents the 1953 minimum value preceding the maximum which will occur in that year.

APPENDIX

Linear Correlation

Data taken from Table 1:

$$\Sigma x = 264.3 \qquad \Sigma y = 376.2 \qquad \Sigma xy = 1243.41$$

$$\Sigma x^2 = 917.71 \qquad \Sigma y^2 = 1720.72$$

$$(\Sigma x)^2 = 69{,}854.5 \qquad (\Sigma y)^2 = 141{,}526.44$$

$$L_{xx} = n\Sigma x^2 - (\Sigma x)^2$$
$$= 91(917.71) - 69854.5$$
$$= 13{,}675.3$$

$$L_{yy} = n\Sigma y^2 - (\Sigma y)^2$$
$$= 91(1720.72) - 141{,}526.44$$
$$= 15{,}059.08$$

$$L_{xy} = n\Sigma xy - (\Sigma x)(\Sigma y)$$
$$= 91(1243.41) - (264.3 \times 376.2)$$
$$= 13{,}720.65$$

$$C_1 = \frac{L_{xy}}{L_{xx}} = \frac{13{,}720.65}{13{,}675.3} = 1.003$$

$$C_0 = \frac{\Sigma y - C_1 \Sigma x}{n} = \frac{376.2 - (1.003 \times 264.3)}{91} = 1.22$$

$$r_{xy} = \frac{L_{xy}}{(L_{xx}L_{yy})^{\frac{1}{2}}} = \frac{13{,}720.6}{(13{,}675.3 \times 15{,}059.1)^{\frac{1}{2}}} = 0.956$$

Equation of Line AA:

$$y = C_1 x + C_0$$
$$= 1.003x + 1.22$$

$$\sigma_Z = \frac{1}{(n-1)^{\frac{1}{2}}} = \frac{1}{(90)^{\frac{1}{2}}} = 0.105$$

$\therefore$ Variation by chance alone between

$$0 \pm 3\sigma \quad \text{or} \quad 0 \pm 3(0.105) = 0 \pm 0.315$$

$$\sigma_E = \frac{1}{n}\left(\frac{L_{yy}L_{xx} - L_{xy}^2}{L_{xx}}\right)^{\frac{1}{2}} = \frac{1}{91}\left(\frac{15{,}059 \times 13{,}675 - (13{,}720)^2}{13{,}675}\right)^{\frac{1}{2}}$$

$$\sigma_E = 0.4013$$

$$2\sigma_E = 0.8026$$

$$3\sigma_E = 1.204$$

Experiments With Fresh-Water Barrier to Prevent Sea Water Intrusion

By Paul Baumann

A paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by Paul Baumann, Asst. Chief Engr., Los Angeles County Flood Control Dist., Los Angeles.

DURING the past 30 years the intrusion of sea water into ground water basins along the coast of California and inland bays has been observed with increasing alarm. Indeed, the California Div. of Water Resources reported in December 1950 that, of a total of 79 such ground water basins, 19 were more or less seriously affected by sea water intrusion and the others potentially subject thereto (*1*). Two of these basins—the Central Coastal Basin in Orange County and the West Coast Basin ("West Basin" for short) in Los Angeles County—were described as those most seriously affected. The Los Angeles County Flood Control Dist., created in 1915 by the state legislature and charged with the responsibility for flood control and water conservation, had been aware of sea water intrusion along the coastline under its jurisdiction, particularly that affecting the West Basin. The deterioration of the principal aquifer and a water resource of inestimable value, the Silverado Zone, had been accelerated by the combination of greatly increased ground water extraction due to industrial and domestic demand, and greatly decreased replenishment due to seven consecutive years of subnormal rainfall. This condition is clearly brought out in Fig. 1, which shows the ground water contours or pressure levels as of spring 1951. Conspicuous are the two principal pumping areas with water levels of −50 ft or lower.

It became obvious that steps had to be taken to stem sea water intrusion without delay in order to save the Silverado water-bearing zone in this area from destruction.

Sea water intrusion into a depleted ground water basin may well be likened to an infectious disease certain to spell the doom of a weakened patient unless effectively counteracted. Two principal types of "patients" must be considered: the open and the confined types of aquifers. The treatment differs for each type. Of the exposed Silverado Zone of the 12-mile West Basin coastline north of the Palos Verdes Hills, approximately one-third is of the open, and the balance of the confined, aquifer type. The boundaries are indicated in Fig. 1.

Early in 1950 the district embarked on a pilot test program which included spreading tests on 1-acre plots in each of the two open or quasi-open areas near Redondo Beach and El Segundo and a recharge test on one of the abandoned wells of the city of Manhattan Beach. The results of these tests, which extended over the major part

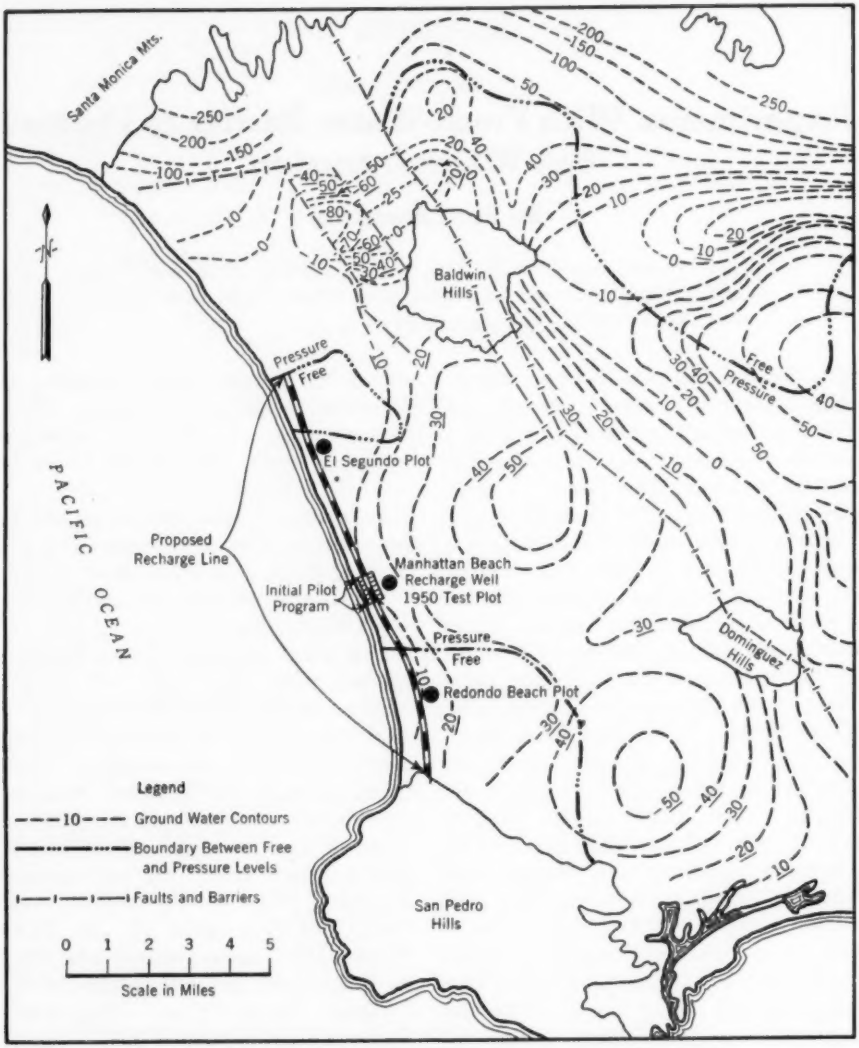

Fig. 1. West Basin Ground Water Contours (Spring 1951)

The map shows the ground water contours or pressure levels (in feet) in the West Coast Basin of Los Angeles County. (Negative figures are underlined.) Also shown are the test sites and the proposed recharge line.

of the year, were reported (*2*) by the district early in 1951. Based on these results, plans for a fresh-water barrier were presented, one extending over a front approximately 1 mile in length and the other covering the entire 12-mile section of coastline. The pilot tests were preceded and paral-

leled by research on ground water phenomena related to spreading, including laboratory model experiments (*3*).

As a result of these activities, combined with the efforts of the West Basin Water Assn., the 1951 session of the state legislature passed a bill calling for an appropriation of $750,000, to be administered by the California Board of Water Resources, for large-scale tests on fresh-water barriers in the West Basin of Los Angeles County and other areas in the state to prevent sea water intrusion. On Oct. 1, 1951, a contract was entered into between the water resources board and the flood control district which called for the latter, under the supervision of the California Div. of Water Resources, to engineer a large-scale test. Its purpose was to investigate the feasibility of stemming sea water intrusion, over a distance of approximately 1 mile, into the confined Silverado Zone near Manhattan Beach. The sum of $450,000 was allocated to this contract.

Spreading Plots

The locations of the spreading plots upon the sand dunes near Redondo Beach and El Segundo, and of the recharge well in Manhattan Beach, are indicated in Fig. 1.

The primary purposes of the spreading plots were: [1] to ascertain the rate of infiltration which could be sustained over an indefinite period of time and the treatment of the water needed to assure the maintenance of such a rate; [2] to ascertain the continuity of soil permeability between the spreading basin and the ground water table; and [3] to observe the formation and configuration of the mound above the initial ground water table and, particularly, its rate of growth.

To obtain this information, observation and sampling wells were installed on the extension of the two principal axes of the square plots, which had a wetted area of 1 acre and a water depth of approximately 2 ft. Difficulties were encountered at the El Segundo (also known as Imperial) plot. There the sand dunes were capped with a sandy loam of low permeability, 20–25 ft in depth. Because its removal was impracticable, a novel treatment was resorted to. This took the form of 30-in. seepage pits, drilled with a bucket rig through the tight formation and subsequently filled with clean pea gravel of uniform size. The pits, 25 in all, were arranged on a 40×40-ft grid and extended far enough below the loam formation to terminate in permeable dune sand.

Both the well water used at the Redondo Beach plot and the Los Angeles city water at the El Segundo plot required treatment to prevent or to overcome the formation of bacterial slime and algae. At Redondo Beach, chlorine was used in dosages averaging approximately 8 ppm, while calcium hypochlorite and copper sulfate were employed at El Segundo. A total of 177 lb of calcium hypochlorite and 320 lb of copper sulfate was used to treat 262 acre-ft of Los Angeles city water.

These plot tests showed that:

1. With proper treatment of the water, spreading rates on the order of 2 cfs per wetted acre could be maintained.

2. The gravitational seepage path of "rain" between the spreading basin and the ground water table of the Silverado Zone was impeded by clay lenses of limited expanse in the Redondo Beach dune area and by clay formations of considerable expanse at El Segundo. Consequently, in the first

mentioned area, the formation of the mound, definitely observed, was associated with a lag and affected by a great reduction in the rate of supply relative to the rate of infiltration. At El Segundo, no mound formation on the water table of the Silverado Zone was observed in the course of the test. Hence, during a period of approximately 80 days the seepage from the pits through the dune sand was intercepted and perched upon less permeable strata.

3. The results obtained from 1-acre plots could not be considered conclusive if applied to an area of many hundreds of acres. The possibility of adverse local conditions naturally existed. Further tests on a large scale were therefore indispensable prior to the development of the final project.

Recharge Well

In view of the predominating proportion of the confined aquifer type, the recharge test on the Manhattan Beach well was the most significant of the three pilot tests. This well, known as No. 7, had been abandoned by the city because of its high salinity. Immediately preceding the test, samples from the well showed chloride on the order of 1,200 ppm. It was expected that the test would give results which, when expressed in the usual ground water parameters, could be applied to other locations in the basin or, in fact, to any other basin of a similar type. It was anticipated that information would be obtained on:

1. The rate of fresh water injection which could be maintained and the measures necessary for its assurance.

2. The degree of mixing of injected fresh water with saline water, or the degree of displacement along the interface.

3. The effect on neighboring wells of a saline wave resulting from such a displacement.

4. The extent to which the fresh water would override the saline water.

5. The degree of confinement of the Silverado Zone at this location in terms of pressure rise and pressure drop at the starting and stopping of injection.

6. The shape and extent of the pressure "cone of expression."

7. The rate of movement of the injected fresh water relative to the initial ground water movement.

Well No. 7 is a 16-in. cased well 350 ft in depth, with 32 ft of standard slot perforations in the Silverado Zone starting 230 ft below the surface of the ground (el 157). The well penetrates the clay cap, 60 ft in effective thickness with its top 165 ft below the surface, which forms the upper confinement of the zone. The perforations coincide with the most permeable part of the zone. The piezometric water level was at el −16, or 173 ft below the ground surface. Hence, a corresponding injection head was possible with atmospheric pressure acting on the water surface.

The well had been equipped with a turbine pump capable of extracting 320 gpm at a drawdown of 22 ft. The water was measured through a stilling box and weir at the well. The water injected was partly Manhattan Beach water from inland wells and partly treated Colorado River water from the Metropolitan Water Dist. Injection of fresh water started in May and was terminated in October 1950. After 12 weeks of recharge, during which 190 acre-ft was injected, the pump was reinstalled, the well pumped for 10 hours, and the extracted water periodically sampled. It was thereby established

that the mineral constituents of the water extracted checked precisely with those of the water injected. Evidently the initial saline water had been displaced and replaced by the injected fresh water. This finding was of fundamental significance in the ultimate solution of the problem.

The effect of the injections on six existing neighboring wells and on three newly installed test wells was observed. In addition to the one on No. 7, automatic water stage recorders at wells No. 1 and 8 as a result of the injection. Of special interest are the arrival and passage of the saline wave at Well No. 8 and the rapid "sweetening" of the ground water at Well No. 1 without evidence of a preliminary saline wave. No initial sampling took place at Well No. 1.

The test brought out that the principal nonhydraulic cause of impedance of recharge with clear, potable water was its oxygen content. The formation of bacterial slime in the pores of

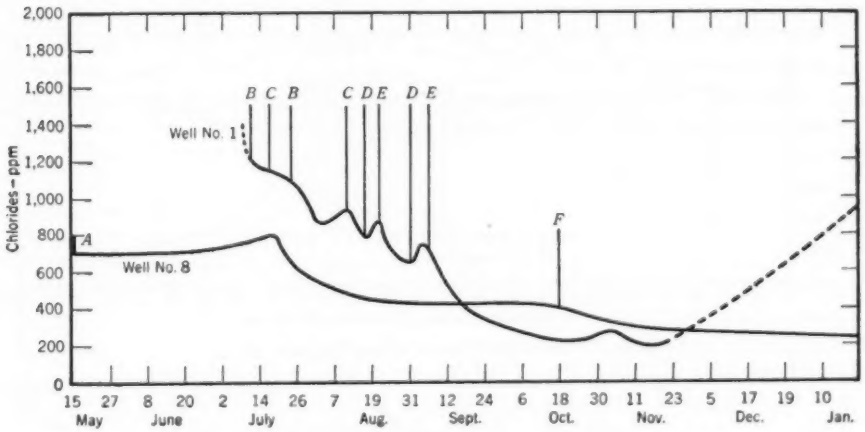

Fig. 2. Effect of Recharge on Chloride Concentration

The graph shows how two Manhattan Beach wells were affected by the 1950 recharge test. Key: A—*recharge begun;* B—*injection reduced;* C—*injection increased;* D—*injection halted;* E—*injection resumed;* F—*recharge ended.*

were installed on four of the existing wells—No. 3, 1, 4, and 6—which were, respectively, 171, 376, and 417 ft. south and 125 ft west of Well No. 7. Periodic water surface measurements well made at wells No. 8 and 14 and at three test wells, installed by the district, east of Well No. 7. The hydraulic pressure line of the ground water slopes between 2 and 4 ft per thousand, generally from west to east. Figure 2 shows the change in chlorides

the soil resulted from the stimulation of microorganisms previously dormant in the ground water in the absence of oxygen. To assure freedom from such impedance, deaeration and chlorination or some other effective treatment of the injected fresh water is an indispensable measure. Aeration was minimized through the use of a 6-in. insert pipe with a specially designed foot valve. This pipe was kept full during injection, and agitation of the

injected water between the measuring weir and the pipe was held to a minimum. Standard chlorinating equipment was used during the latter 36 days of the test. The minimum effective dosage was found to be approximately 10 ppm.

The following information was obtained on the seven principal points previously set forth:

1. With proper treatment of the water from the very start of the test, a 2-cfs rate of injection could have been maintained at maximum head.

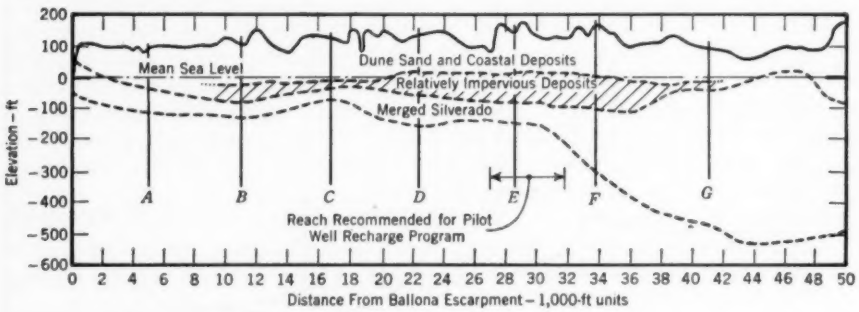

Fig. 3. Geologic Profile Along Barrier Front

Key: A—*Century Blvd.;* B—*Imperial Highway;* C—*El Segundo Blvd.;* D—*Rosecrans Ave.;* E—*Center St.;* F—*Redondo Beach Blvd.;* G—*north city limits of Redondo Beach.*

2. The injected fresh water did not mix with the saline water. The latter was displaced completely at least to the full depth of the perforations of Well No. 7. Facilities for observation and the number of suitable wells were alike inadequate to determine the location of the interface.

3. The creation of a saline wave preceding the fresh injected water in the direction of the maximum (easterly) gradient was clearly manifested in the increase in chloride concentration at Well No. 8. The intensity of this increase, however, is such as to indicate predominantly lateral displacement of the saline water at Well No. 7 and overriding thereof by the fresh water in an easterly direction.

4. Overriding of saline water by fresh water increased with the distance from the point of injection.

5. The pressure increase and decrease with the starting and stopping of injection was nearly instantaneous, indicating a well-confined aquifer.

6. The configuration of the pressure mound (cone of expression) was found to be symmetrical, relative to the east-west and north-south vertical planes, for rates of injection varying from 0.63 to 2.07 cfs. The rise of the mound was substantially in direct proportion to the rate of injection.

7. The rate of movement of the injected water under the gradient created between wells No. 7 and No. 8 was approximately 8 ft per day, or roughly twice that of the initial saline water.

Economic Considerations

The technical information derived from the pilot tests was associated with cost data to arrive at the estimated cost of the proposed large-scale test in the Manhattan Beach area, as well as the

ultimate cost of a liquid barrier extending over the entire 12-mile front between the Ballona escarpment and the Palos Verdes Hills. Considerable caution is, of course, in order when results of small-scale tests are extrapolated to apply to a project of much larger dimensions. It was therefore felt that conclusions regarding the cost of the ultimate project should be withheld pending completion of the large-scale test. It was, however, possible to evaluate, within their apparent limitations, such quantities as the number of wells and seepage pits required and the rate of injection or infiltration necessary to maintain a liquid barrier to mean sea level or above. The height above mean sea level depends, as is well known, on the gravity of the injected water relative to that of the saline water which is to be retained by the barrier. It is, therefore, with certain reservations that reference is made to Fig. 1, which suggests the arrangement of the ultimate project, and to Fig. 3, which indicates the characteristics of a longitudinal geologic profile along the barrier front.

Based on the premises discussed, a supply of fresh water of 133–169 cfs is indicated, at least initially, for the maintenance of a barrier capable of stemming sea water intrusion over the entire 12-mile front.

A large-scale test of this nature and scope necessarily involves theoretical, practical, and experimental phases. The essentials of the latter two were described in 1952 by F. B. Laverty (*4*), Chief, Hydr. Div., Los Angeles County Flood Control Dist. This article, however, was prepared before the work contracted for by the California Board of Water Resources was started. It therefore appears timely to bring the information up to date, but, before doing so, it is believed desirable to treat briefly the theoretical background of the proposed test.

Theoretical Phase

Although standard textbooks offer quite liberal information on ground water hydraulics related to water-extracting wells, little, if any, technical information has been available on recharge wells until recent times. In the light of this absence of information, it is understandable why recharge wells have been treated as comparable to extraction wells, although actually they are likely to be nothing of the sort. In the extraction well, the seepage surface—that is, the perforated well casing—through which the ground water emerges into the open, acts as a control, which is absent in the recharge well. Therefore, the former is associated with steady flow (except for the short initial period of drawdown) and the latter with unsteady flow. This means that, for a constant rate of extraction from a static ground water body, the drawdown of the water-extracting well remains constant, whereas the "cone of expression," that is, the mound due to a constant rate of injection into a recharge well, cannot remain constant but must continue to rise until it reaches the surface. Thus, the injected water flows away from the well in the form of a wave which spreads radially in the course of time; the rate of flow through this wave varies from the rate of injection at the well to zero at the front of the wave. It is axiomatic that the rate of injection must decrease once the mound has reached the surface and thus attained the limit of its vertical growth. Subsequent to this event, the slope of the wave must flatten as it continues to spread, and, consequently,

the velocities and the rate of flow must decrease.

Basically, a circular spreading ground and a recharge well in an open aquifer are one and the same thing. They are a three-dimensional phenomenon, contrary to a line of seepage pits, closely spaced, or to a strip spreading area, which represents a two-dimensional phenomenon. In either instance, however, the ground water movement is governed by Darcy's law which states that its velocity is equal to a constant, the permeability coefficient, times the slope of the hydraulic gradient. Obviously, the velocity equals the permeability coefficient if the slope of the gradient is unity. Fundamentally, then, the movement of ground water differs from that of surface water in that its depth has no effect on the velocity. These concepts are elementary but nevertheless important.

If the ground water table or gradient is not horizontal—that is, if an initial slope exists and, therefore, an initial ground water movement—the three-dimensional problem becomes quite involved. The paths of the streamlines emerging from the well are then no longer straight and along radial lines, but are curved. The concentric circles, typical for the wave front on a static ground water table,

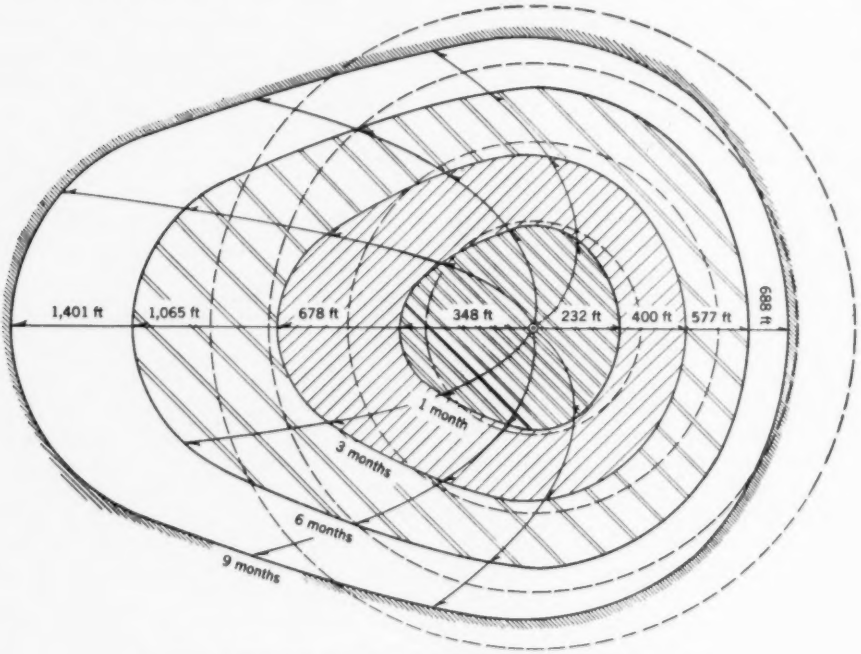

Fig. 4. Estimated Rate of Advance of Recharge Water

The broken circles indicate the rate of advance on a level ground water plane and the solid-line ellipsoids, the rate on an inclined ground water plane.

becomes elongated in a downstream direction and blunted in an upstream direction. The injected water assumes the shape of an ever-lengthening bulb. At all times, however, the volume of the injected water in the pores of the soil must be equal to the rate of injection times the duration of injection. In principle, the phenomenon is the same whether the aquifer be open or confined. The analysis of the latter is less involved if its magnitude may be considered constant.

Figures 4 and 5 show the graphical analysis of the shape of the fresh-water bulb in terms of time at a typical section of the test site. The effective magnitude of the confined aquifer, shown in Fig. 5, is assumed to be 100 ft. The pressure gradient required to effect the movement as shown, in accordance with Darcy's law, is indicated. It implies that the pressure head required will be small in relation to the total available.

In the course of time, as the elongation of the bulb shown in Fig. 4 continues, it will change its shape to that of a ground water stream, with the wider portion in a downstream direction. Considering one injection well and assuming complete displacement of the initial saline water by the injected water, the width of the stream is determined by the ratio of the rate of injection to the rate of initial ground water flow per linear foot. As opposed to the growing bulb, this condition of ground water stream flow, being stationary, can be expressed in mathematical terms. Hence, between the unsteady flow associated with a recharge well in a static ground water body and the final stage of stationary

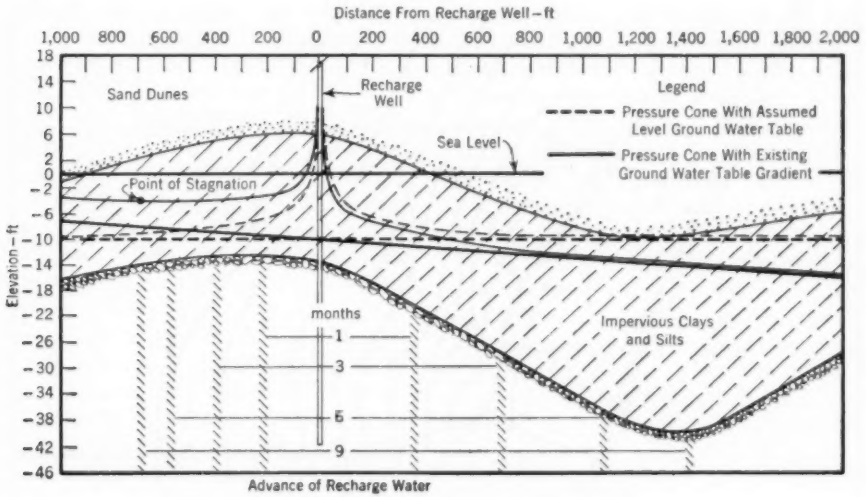
Distance From Recharge Well – ft
1,000 800 600 400 200 0 200 400 600 800 1,000 1,200 1,400 1,600 1,800 2,000
Elevation – ft
18 14 10 6 2 0 –2 –6 –10 –14 –18 –22 –26 –30 –34 –38 –42 –46
Sand Dunes
Recharge Well
Sea Level
Point of Stagnation
Legend
Pressure Cone With Assumed Level Ground Water Table
Pressure Cone With Existing Ground Water Table Gradient
months
1
3
5
9
Impervious Clays and Silts
Advance of Recharge Water

Fig. 5. Estimated Profile of Recharge Cone

The profile estimate assumes a homogeneous aquifer (Silverado) of uniform magnitude (100 ft).

flow from a recharge well into an inclined ground water body, both of which lend themselves to mathematical analysis, there is, so to speak, a mathematical vacuum, a no man's land which has so far defied exact, analytical treatment. This fact brings home the realization that much work remains to be done in connection with three-dimensional ground water phenomena.

The dissipation or diffusion of the bulb upon discontinuation of injection also falls into this category. It seems logical that the bulb must cease to grow and to elongate upon removal of the source of energy—namely, the higher potential of the injected flow relative to the initial flow. Deprived of this driving force, the fresh-water bulb will merely "float" in the saline

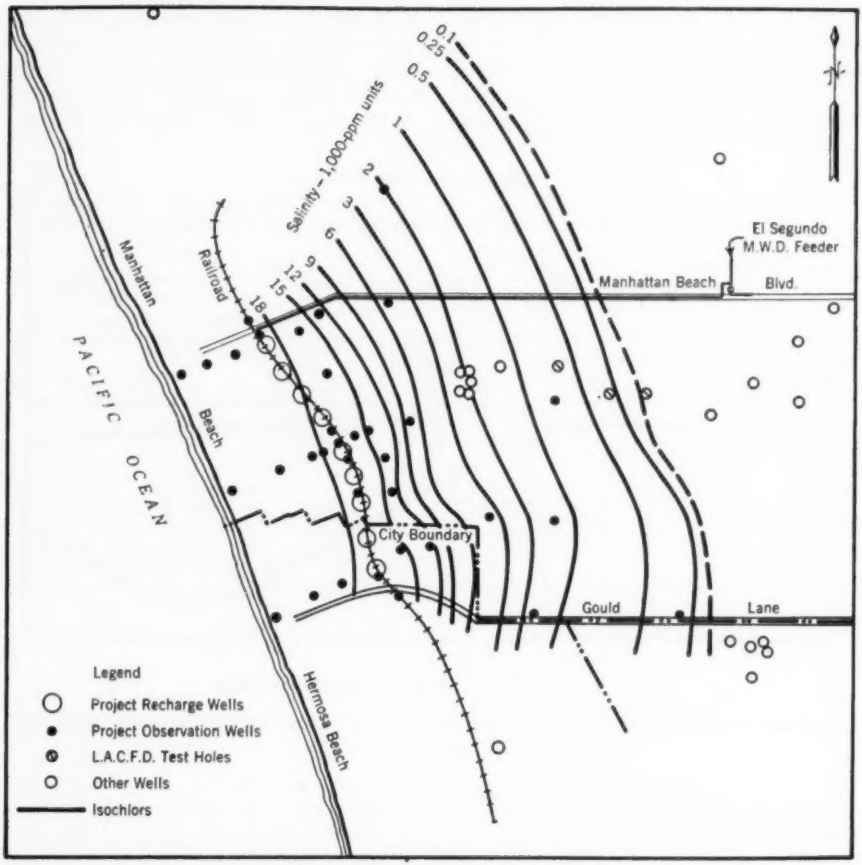

Fig. 6. Well Locations and Isochlors

The location of project and other wells, both producing and abandoned, is shown. The isochlors indicate the extent of sea water intrusion in the West Basin.

stream and will diffuse in time through mixing with the latter. This does not conflict with the idiosyncrasies of a density current, which a saline ground water stream naturally is, in relation to fresh water. Similar diffusion, although in reverse, has been observed attending turbid density currents when the closing of outlets interferes with their potential passage through reservoirs. The fact that the injected fresh water "cuts" through the saline water without mixing under the impetus of its higher potential, is, of course, of prime importance. Much less fresh water is required to displace the saline water than would be necessary if the salinity had to be removed by mixing with the fresh water.

The West Basin test site provides a good illustration of this point. It is expected that approximately 3,000 acre-ft of fresh water will be required, in the course of the test, to displace the saline water within a 1-mile wide strip, whereas it was estimated by the water resources division that approximately 120,000 acre-ft of fresh water with 80 ppm chlorides or less would be required to reduce the salinity to a maximum of 250 ppm. The chloride concentration along a section through the center of, and at right angles to, the test site will be described later.

The maximum spacing of the recharge wells, consistent with a pressure barrier approximately 2 ft above mean sea level at the lowest point, is of prime interest in the test. It is obvious that a reduction in the spacing of the wells will eventually lead to the equivalent of a strip area, and, therefore, to a two-dimensional condition. Although not a part of the present test program, such a proposal has been made for the open aquifer from Redondo Beach south, where shallow seepage pits would have to be placed approximately 50 ft apart. Instead of a pressure barrier, a mound would then be produced above the initial ground water table. This mound or ridge would have to be caused to rise to mean sea level or somewhat above.

Actually, sea water intrusion will be checked when the infiltrated water reaches the initial water table, as the mound will slope from the center of the strip in both directions. Hence, a negative slope or counterslope will form in an upstream direction through which the saline water cannot pass. Naturally, the rate of that part of the injected water flowing in the downstream direction must be greater than the initial rate of ground water flow if the mound is to grow as required. During this period the initial ground water flow, together with that part of the infiltrated water flowing in the opposite direction, will go into storage in the backwater prism upstream from the spreading strip. In the absence of a downstream control, the barrier will continue to rise until it reaches the surfaces of the spreading basins or seepage pits.

It has been suggested that, theoretically, a pumping trough would be as effective as a pressure ridge or mound in stemming sea water intrusion. This contention merits close scrutiny. Leaving economics, other than in general terms, out of consideration and confining the problem purely to the mechanics of a pumping trough, the following features appear to be obvious:

1. The trough would necessarily have to be located parallel and close to the seashore, that is, in the region of high salinity.

2. In view of the landward gradient associated with sea water intrusion,

the drawdown on the landward side of the trough would be more severe than on the seaward side. In fact, the reversal of the direction of flow from landward to seaward—that is, toward the trough—could well result in an enhanced, critical depletion of the basin.

3. The landward gradient on the seaward side of the trough would be made steeper, thereby giving rise to increased sea water intrusion. Under certain conditions, this could result in "piping" and, thus, could prove disastrous.

4. Considerable quantities of potable water, drawn to the trough from inland, would have to be wasted.

5. This method of "control" of sea water intrusion would result in depletion rather than in replenishment of the basin.

6. The cost of such an operation might well prove greater than that of a fresh-water barrier.

Practical Phase

Figure 6 shows the general layout of the large-scale test installation. Through the cooperation of the Santa Fe Railway, it was possible to locate, on its Redondo Beach line right of way, five 12-in. recharge wells, spaced 1,000 ft apart, with four auxiliary 12-in. recharge wells halfway between them. The right of way, 100 ft in width, runs roughly parallel to, and 2,000 ft inland from, the coast. A total of 36 8-in. observation wells are arranged thus: 10 wells seaward from the Santa Fe right of way, that is, from the test front; 9 along the test front, 20–250 ft from the recharge wells; and 17 landward from the test front, at distances of roughly 250, 500, 1,000, and 2,000 ft from it.

All of the wells extend into the Silverado Zone and are perforated in the cleanest, most permeable strata. The perforations of the observation wells were cut vertically with a standard ¼-in. knife, generally five cuts to the round horizontally and spaced 8 in. vertically. The recharge wells, both primary and auxiliary, were perforated horizontally with a louver type knife, eight cuts to the round horizontally and spaced 4 in. vertically with the alternate rows staggered.

One of the recharge wells will be gravel packed. The water will be supplied to the recharge wells through a feeder line which starts at the vault of El Segundo's connection to the Metropolitan Water Dist. supply line, runs westerly along the south side of Manhattan Beach Boulevard to the Santa Fe right of way, and then turns south along the latter. The line comprises roughly 10,000 ft of 20-in. and 1,000 ft each of 16-in. and 14-in. OD steel pipe. Approximately 2 miles of the feeder line are located within the city limits of Manhattan Beach and the balance, within those of Hermosa Beach. The cooperation of the three cities mentioned has been exemplary.

Facilities are provided for chlorination of the water and for its injection under the maximum available working pressure of approximately 150 psi. The average pressure head at the vault is 320 ft above sea level. Injection will initially be made at atmospheric pressure. The average ground surface elevation at the test site is approximately 108 ft above sea level.

In the course of the well installation, periodic sampling was performed to determine the chloride content of the saline water. Figure 6 also shows the feeder line, the project wells, and the producing and abandoned wells of the principal water users. Superimposed on this map are isochlors, which show

at a glance the extent of sea water intrusion in this part of the basin and the threat to some of the producing wells. The seriousness of the situation had not been fully realized prior to the installation of the project wells.

Figure 7, which shows the salinity profile of the test area in terms of average chloride concentration, brings out certain essentials a little more impressively than does Fig. 6. Above all, it should be noted that the chloride concentration at the test site is substantially that of sea water. Hence, this site is the real saline front rather than the 250-ppm isochlor. Significant is the rapid, wavelike decline immediately landward from the test front. It is obvious that, in this region, even a small landward advance of the wave means a considerable increase in chlorides. Actually, the configuration of this chloride concentration represents the density current previously mentioned. A smaller wave front, not visible in Fig. 7, is at the landward end of the configuration. There the chloride concentration, before leveling off, rises rapidly from a typical minimum of approximately 80 ppm to approximately 300 ppm. Consequently, a corresponding increase in chlorides is to be expected with a relatively short advance of the wave front.

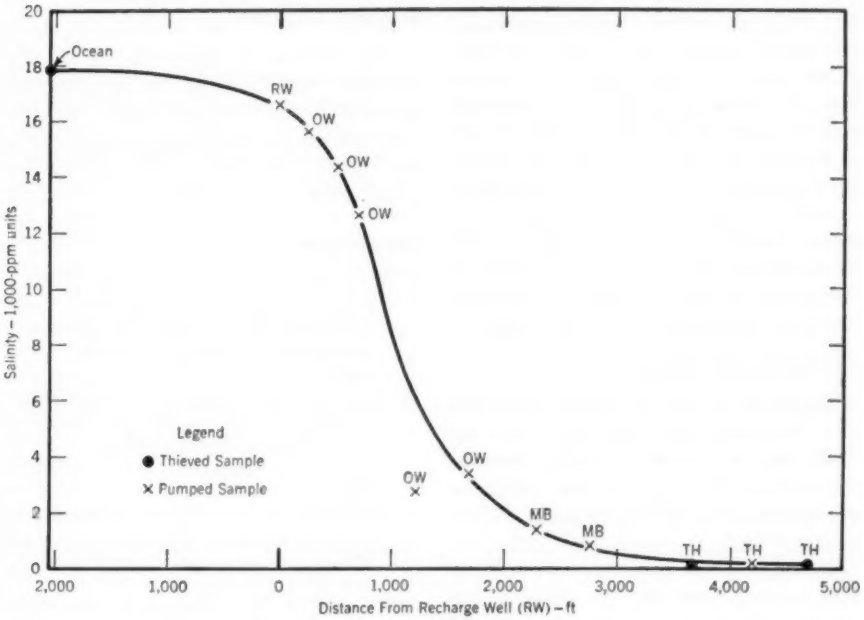

Fig. 7. Salinity Profile of Test Area

Key: RW—recharge well; OW—observation wells; MB—Manhattan Beach wells; TH—test holes. The salinity limit for potable water is usually given as 250 ppm.

Fear has been expressed that the injection of fresh water might create a saline wave. In view of the distance between the test site and the produc-

ing wells, the intensity of this wave, which in time, through continuous injection, would reach these wells, is believed to be insignificant as compared to the intensity of the intrusion wave itself if nothing were done to stop it. Based on the record at Manhattan Beach Well No. 8 (Fig. 2), and assuming the existence of similar soil conditions, it has been calculated that the chloride increase resulting from the test, even if carried on over an indefinite period, would not exceed 125 ppm at the nearest water wells shown in Fig. 6. Furthermore, it is believed that, by starting injection at the center of the test site and moving symmetrically toward the ends, this increase would be reduced. In this manner, the major quantity of saline water would be displaced laterally into regions of the aquifer where productive extraction has been abandoned for many years.

Experimental Phase

The start of the recharge operations had originally been set for Oct. 15, 1952, but, as a result of delays beyond the district's control, the date had to be postponed until the latter half of February 1953.

Because of the extent of the installation and, particularly, the number and distribution of the observation wells, it is expected that essential information will be secured on all of the pertinent aspects of the problem, as previously discussed. It is hoped that the results can be expressed in terms of ground water parameters so that their application to other, similarly infected basins in California will be possible. In any event, it seems reasonable to believe that the assets of the test will greatly outweigh the liabilities.

Acknowledgment

The author is indebted to H. E. Hedger, Chief Engr., Los Angeles County Flood Control Dist., for his encouragement and suggestions and to the district staff for assistance in the preparation of this paper.

References

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2. Tests for the Creation of Fresh-Water Barriers to Prevent Salinity Intrusion. Los Angeles County Flood Control Dist., Los Angeles (1951). (Out of print.)
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Metallic-Cation Removal as an Aid in Volumetric Sulfate Determinations

By Wilber G. Hunt Jr.

A paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by Wilber G. Hunt Jr., Chemist, Metropolitan Water Dist. of Southern California, La Verne, Calif.

IN view of the wide acceptance of the procedure for the determination of calcium and magnesium in water volumetrically with ethylenediaminetetraacetic acid (EDTA), a number of investigators have directed their efforts toward the use of this method for the determination of other cations. Among the modifications which have aroused the greatest interest are those which will permit the accurate determination of barium, as success in this would lead to a rapid and accurate indirect method for the estimation of sulfate ion in water.

Earlier investigations by the Metropolitan Water Dist. staff and others indicated that barium could be titrated by standard EDTA solution in the presence of Eriochrome black T or similar indicators, but all reports agreed that the color change at the endpoint was not sufficiently sharp to permit an accurate measure of the barium present. Several useful modifications were suggested from time to time by various investigators, but none offered a wholly satisfactory solution to this problem.

Recently, when more intensive study of this procedure was resumed in the district laboratory, it was observed that excellent recoveries were obtained from standard sulfuric acid, whereas those obtained from standard potassium sulfate solution were far from satisfactory. In the latter instance, the objectionable feature was the poorly defined endpoint which produced either high or low results. Munger, Nippler, and Ingols (*1*) noted that the addition of small amounts of sodium chloride, as recommended for the turbidimetric determination of sulfate to improve precipitation, actually tended to lessen the reliability of the results derived from the volumetric EDTA method.

In an effort to obtain sharper endpoints in sulfate determinations involving waters high in sodium, each sample was passed through a column of resinous cation exchanger which had been regenerated in the hydrogen cycle. The resulting mineral acid mixture was then treated according to the procedure to be described. The results checked well with those obtained from the same samples by the standard gravimetric procedure.

Reagents

1. *Standard EDTA solution, ammonium chloride–ammonium hydroxide buffer, and indicator solution.* All are the same as those used for the total-hardness determination.

2. *Barium chloride solution.* Use 0.02*N* barium chloride solution for samples with less than 150 ppm of sulfate, and 0.04*N* for samples with more than 150 ppm. Standardize against 0.02*N* EDTA solution.

3. *Magnesium chloride solution.* Use 0.02*N* magnesium chloride solution, standardized against 0.02*N* EDTA solution.

4. *Cation exchanger.* Use a resin (for example, Amberlite IR–112 *) regenerated in the hydrogen cycle as recommended by the manufacturer. The regenerated, washed resin should be stored in water. If used in a column, it should be free of entrapped air, and a visible amount of water should be maintained above the top of the resin column at all times.

Procedure

Pass the sample through a column of cation exchanger, and waste a first fraction of the effluent in an amount approximately equal to the volume of the resin in the column (100 ml of resin is a convenient amount). Collect a volume of sample sufficient to give the desired number of 50-ml portions. Rinse the column between samples with a volume of distilled water approximately double that of the resin in the column. If a large number of samples is to be run at the same time, a batch method of cation exchanger treatment may prove more convenient. To a volume of sample approximately 25 per cent greater than that required for the determination, add prepared resin which has been drained over a vacuum. The amount of resin necessary must be determined experimentally for each individual product. The water, after treatment, must be entirely free of calcium and magnesium, and the residual sodium and potassium should not be more than a few parts per million. Complete removal is not possible in a single treatment with a convenient quantity of resin. Heat to boiling a 50-ml aliquot of the sample just treated with the ion exchanger, and add an amount of standard barium chloride sufficient to give a barium ion concentration approximately double that necessary to precipitate the sulfate ion in the sample. Allow the sample to cool, and titrate against EDTA to an initial (usually indistinct) endpoint. A known quantity of 0.02*N* magnesium chloride is added, and the titration is continued to a second, sharper, endpoint.

Sulfate is calculated from the equation:

$$\frac{B + M - T}{S} \times 48 = \text{ppm } SO_4$$

in which B is the number of milliequivalents of barium ion added; M is the number of milliequivalents of magnesium ion added; T is the number of milliequivalents of EDTA required in the titration; and S is the volume of the sample, in fractions of a liter.

Results

A number of samples of natural water (all containing relatively high concentrations of sodium), the sulfate concentrations of which had been determined reliably by the standard gravimetric method, were analyzed for sulfate by the earlier EDTA method and again by the modification described in this paper. As shown in Table 1, the variations between the earlier EDTA method and the standard gravimetric method ranged from zero to 3.7 per

* A product of Rohm & Haas Co., Philadelphia.

cent, and the variations between the modified method and the gravimetric determinations ranged from zero to 1.8 per cent, the average numerical variations being 1.3 and 0.5 per cent, respectively.

After treating 15.0 ml of 0.0202*N* sulfuric acid (equivalent to a 50-ml aliquot of water containing 291 ppm of sulfate) according to the procedure described, a value of 292 ppm resulted, a variation of + 0.3 per cent. A 0.006*N* potassium sulfate solution (289 ppm of sulfate) gave values of 289, 283, and 287 ppm for the gravimetric, earlier EDTA, and modified EDTA methods, respectively. Here the variations were − 2.1 and − 0.7 per cent.

Discussion

The overall accuracy of the volumetric EDTA determination of sulfate was improved for waters high in sodium or potassium by the removal of the metallic cations.

In view of these encouraging results, this modification was applied to samples of a variety of natural waters which were received in the district laboratory. For those waters which

TABLE 1

Results of Sulfate Determinations by Modified EDTA Method

Sample*	SO_4 Determined—*ppm*			Na *ppm*	K *ppm*	Total Hardness as $CaCO_3$ *ppm*	Variation From Gravimetric Method *per cent*	
	Gravimetric	Earlier EDTA†	Modified EDTA‡				Earlier EDTA†	Modified EDTA‡
Std. 1	(291)	292					+0.3	
Std. 2	289	283	287	0	235		−2.1	−0.7
1	189	182	187	58	3	236	−3.7	−1.1
2	204	205	204	63	3	254	+0.5	0
3	251	251	251	78	4	297	0	0
4	279	282	277	86	4	327	+1.1	−0.7
5	278	288	279	90	4	332	+3.6	+0.4
6	272	279	271	90	4	323	+2.6	−0.4
7	294	295	296	185	4	126	+0.3	+0.7
8	294	302	295	238	3	7	+2.7	+0.3
9	258		259	84	4	311		+0.4
10	187	188	188	58	2	239	+0.5	+0.5
11	184	185	183	56	3	236	+0.5	−0.5
12	171	170	168	51	3	225	−0.6	−1.8
13	243	245	242	74	4	293	+0.8	−0.4
14	246	246	247	77	4	298	0	+0.4
15	250	252	250	79	4	304	+0.8	0
16	251	253	253	80	4	306	+0.8	+0.8
17	247	251	247	77	4	306	+1.6	0
Average numerical variation							1.3	0.5

* All samples from natural waters except "Std. 1" (standard solution 0.0202*N* H_2SO_4) and "Std. 2" (standard solution 0.006*N* K_2SO_4).
† Without cation removal.
‡ With cation removal.

were not unusually high in sodium, there was not a large overall variation between the initial volumetric EDTA method and the modified one. It should be noted that most of the waters shown in the table had a very high level of hardness. Although insufficient evidence is here presented to permit a definite conclusion, it is not unlikely that the modification will improve the overall accuracy of determinations on hard water, because, in this instance, the calculation of the sulfate is independent of the total-hardness titration. This fact also eliminates the inconvenience of long titrations when making sulfate determinations on very hard waters.

Summary

High levels of alkali metals have been associated with obscured endpoints in the volumetric determination of sulfate, using standard barium chloride and EDTA. Removal of metallic cations by an ion exchanger operating in the hydrogen cycle prior to determining sulfate by the volumetric EDTA method has improved its accuracy with waters high in alkali metals and has simplified the procedure with very hard waters.

Reference

1. MUNGER, J. R.; NIPPLER, R. W.; & INGOLS, R. S. Volumetric Determination of Sulfate Ion. *Anal. Chem.*, **22**: 1455 (1950).

Correction

The "Tentative Standard Specifications for Cast-Iron Pressure Fittings" (AWWA C100–52T), published in the March 1953 JOURNAL, contain an error. In the figure accompanying Table 1 (March issue, page 326), the caption under the right-hand portion reads: "14- to 12-in. Spigots." It should read: "4- to 12-in. Spigots."

AWWA C502-53
(Formerly 7F.3)

American Water Works Association

New England Water Works Association

Standard Specifications

for

FIRE HYDRANTS FOR ORDINARY WATER WORKS SERVICE

The American Water Works Association and the New England Water Works Association have adopted and promulgated these basic "Standard Specifications for Fire Hydrants for Ordinary Water Works Service." They are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned.

Approved as Revised by AWWA Mar. 16, 1953

- **Price of reprint—25¢ per copy**
- **Approximate date available—July 15, 1953**

AMERICAN WATER WORKS ASSOCIATION
Incorporated
521 Fifth Avenue, New York 17, N.Y.

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Appendix

Characteristics of National Standard Fire-Hose Coupling Screw Thread

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as a part of the May 1953 Journal AWWA

Foreword

These specifications supersede the document first published as "Tentative" in the April 1937 JOURNAL; revised June 1937, August 1938, and January 1940; and published in the August 1940 JOURNAL as "Standard." They are jointly sponsored and promulgated by AWWA and NEWWA.

The revision committee, with R. W. Esty as chairman and R. C. Dennett, R. H. Ellis, H. W. Griswold, L. A. Jackson, R. C. Kennedy, and E. E. Norman as the other members, was appointed in 1944 and charged with the duty of reviewing and revising the 1940 text. This committee filed its report on Dec. 30, 1948. Action upon that report was deferred and discussions of the proposed revisions have been held at various times since. The document was completely rearranged and sent out for review on Sept. 6, 1951. The comments received at that time were taken into account and a text (further revised) was circulated as of Apr. 15, 1952. Following discussions of this draft at the 1952 Conference of AWWA, by direction of the Board of AWWA, an ad hoc task group, consisting of C. H. Capen, R. H. Ellis, H. F. O'Brien, C. H. Simon, and H. E. Jordan, was authorized to develop a consensus and put the text into routine process for approval by the two Associations—AWWA and NEWWA. The text as agreed upon by the special committee was again submitted to the AWWA Board of Directors on Feb. 10, 1953, and was approved by it on Mar. 16, 1953.

These specifications become effective as a basis for purchase Sept. 1, 1953.

The fire hydrant is a unit of water utility property provided for service to the public in an emergency but is operated in such an emergency by firemen—not by water utility employees.

The use of fire hydrants by street-cleaning or sprinkling personnel, by workers on construction projects, and sometimes by city employees to provide mid-summer recreation for children is beyond the primary purpose of fire fighting for which the units are installed. Such irregular uses of hydrants must be rigidly restricted and controlled by the water utility in the interest of keeping the equipment in good working order for use at times of fire.

The water utility, unless expressly relieved by the fire department in accordance with a written agreement or public ordinance, must schedule regular and frequent inspection of hydrants and keep them in good working condition.

Hydrants produced according to these specifications are designed to be operated by one man with a 15-in. wrench—not with a 24-in. wrench nor with an indefinite extender which two or more men handle. If one man using a 15-in. wrench cannot open and close a fire hydrant, it is not in proper working order and should be promptly put in good condition.

In areas where severe winter conditions exist, it is the responsibility of the water utility to see that water does not get into the hydrant barrel and freeze. In some states, health authorities forbid the installation of hydrants with drain valves. In such circumstances, the utility personnel are doubly responsible for maintaining the hydrant operating valve in such good order that water will not leak into the barrel from the main, stand there, and freeze.

Hydrants produced under these specifications are required to meet a test of 200-ft-lb torque applied at the operating nut in both opening and closing directions. This torque is considered fully adequate to operate a hydrant which is in good working condition. Hyrants with barrels longer than 5-ft bury may, however, require special design.

Appended to these specifications are: a tabulation giving the characteristics of the ASA B26 Standard for Fire-Hose Coupling Screw Thread; and the *optional* Specifications for Uniform Marking of Fire Hydrants—AWWA C503 (formerly 7F.3.1).

Standard Specifications for

Fire Hydrants for Ordinary Water Works Service

Foreword—Hydrant Specifications

Sec. 1—Type of Hydrant and Character of Service

1.1. These specifications embrace the various types and classes of hydrants for general water works service. The items described are the various forms of post hydrants with compression (working against or with the pressure) or gate type of shutoff.

1.2. Hydrants shall be designed for a working pressure of 150 psi.

1.3. Hydrants of special design, including those having built-in hose gates, and hydrants designed for higher working pressure are not covered.

1.4. Hydrants which have replaceable "breakable" sections or components are not explicitly covered in later sections of these specifications. It is stipulated, however, that such hydrants shall conform to these specifications in all details except the special bolts or sections which intentionally have a lower breaking point than the rest of the unit.

1.5. These specifications do not cover the wet-barrel or "California" type of hydrant.

1.6. References to the setting and drainage of hydrants are not included in these specifications. For installation standards, see Specifications for Installation of Cast-Iron Water Mains —AWWA C600.

Sec. 2—Supplementary Details to Be Specified

When hydrants are to be purchased under these specifications, the purchaser shall provide specific supplementary information concerning the following details:

2.1. *Type of shutoff*—compression or gate.

2.2. *Inlet connection, size, and type* —bell, flange, or other.

2.3. *Delivery classification*—designated according to the number of hose and pumper nozzles; for example: "two-hose nozzle," "one-pumper nozzle," "one-hose and one-pumper nozzle," "three-hose nozzle," "two-hose and one-pumper nozzle," "three-hose and one-pumper nozzle," "four-hose nozzle," "two-pumper nozzle."

2.4. *Bury length*—in feet (to the nearest ½ ft), measured from the bottom of the connecting pipe to the ground line at the hydrant.

2.5. *Diameter (nominal inside) of hose nozzles and pumper nozzle, if any* —in inches.

2.6. *Hose and pumper nozzle threads* —if in conformity with ASA specifications B26 for "National (American) Standard Fire-Hose Coupling Screw Thread," so specify. If not ASA standard thread, specify the following details or supply a sample:

Outside diameter of male thread finished
Diameter of root of male thread
Number of threads per inch
Pattern of thread
Cut off....in. at top of thread
Leave....in. in bottom of valley.

2.7. *Harnessing lugs*—if required (see Sec. 5.9).

2.8. *Nozzle cap gasket*—if required.

2.9. *Tapping of drain opening to receive threaded pipe*—if required.

2.10. *If hydrant is to be made without drain opening, so specify.*

2.11. *Direction to open*—right (clockwise) or left (counterclockwise).

2.12. *Color of finish paint above ground line.*

2.13. *Shape and size of operating and cap nuts*—see Sec. 5.19.

Sec. 3—Data to Be Furnished by Manufacturer

3.1. After purchase, the manufacturer shall, if requested, furnish catalog data (including illustrations and a schedule of parts and the materials of which they are made) in sufficient detail to serve as a guide in the assembly and taking down of the hydrant, as well as in ordering repair parts.

3.2. When required, the manufacturer shall furnish a statement giving the total net assembled weight of each size of hydrant ordered.

3.3. When required, the manufacturer shall submit, without charge, one set of certified drawings of all parts showing the principal dimensions, construction details, materials used, and the finish thereof, for approval by the purchaser. When approved, no work shall be done or hydrants furnished that are not in accordance with the approved drawings.

Sec. 4—Materials

4.1. *General.* All materials designated hereinafter shall, when used in hydrants produced under these specifications, conform to the specifications designated below for each material listed. When reference is made to ASA, ASTM, or other specifications, it is understood that the latest revision thereof shall apply.

4.2. *Physical and chemical properties of components.* The requirements of ASA, ASTM, or other standard specifications to which reference is made elsewhere in this text shall govern the physical and chemical characteristics of the hydrant components.

4.3. *Standard test procedures for components.* Whenever hydrant components are to be made in conformance with ASA, ASTM, or other specifications, all test requirements or testing procedures specified therein shall be met by the hydrant manufacturer. The records of such tests shall, if required by the purchaser, be made available to him.

4.4. *Cast iron.* All cast iron shall conform to ASTM specifications A126 Class B (Gray Iron Castings for Valves, Flanges, and Pipe Fittings).

4.5. *Wrought iron.* When wrought iron is used, it shall conform to ASTM A84 (Staybolt Wrought Iron).

4.6. *Steel.* Steel shall conform to ASTM A107 (Hot-Rolled Carbon-Steel Bars).

4.7. *Brass or bronze.* Hydrant components made from brass or bronze shall be one of six grades:

Grade I—conforming to ASTM B62

Grade II—conforming to ASTM B132 (Alloy A)

Grade III—conforming to ASTM B132 (Alloy B), B98 (Type D—hard), or B150 (Alloy 1)

Grade IV—rolled bronze (naval brass) conforming to ASTM B21 (Alloy A, one-half hard)

Grade V—conforming to ASTM B147 (Grade 8a)

Grade VI—conforming to ASTM B124 (Grade 2).

4.8. *Bolts and nuts:*

4.8.1. Body bolts and nuts shall conform to ASTM A307 (Grade B). Bolts and nuts shall be either cadmium

plated or zinc coated (ASTM A123), or rustproofed by some other process (Parkerizing, Sherardizing, or the like) disclosed to and acceptable to the purchaser. Body bolt studs shall conform to the physical and threading requirements of ASTM A307 (Grade B).

4.8.2. Gland bolts may be made of either Grade II, III, or IV bronze or rustproofed steel in accordance with Sec. 4.8.1 of these specifications. Gland bolt nuts shall be made of Grade II, III, or IV bronze.

4.8.3. Stuffing box bolts and nuts shall conform to Sec. 4.8.1 above; *or*, if bronze is used, it shall be Grade II, III, IV, or V.

4.9. *Packing.* Stuffing box packing shall be made of asbestos conforming to Navy Department Specification 33–P–26–b (Type A) or flax conforming to Federal Specification HH–P–106c; or O ring seal may be used. Hemp packing shall not be used.

4.10. *Gaskets.* Gasket material shall be sheet asbestos, rubber composition, or paper free from corrosive ingredients, either alkaline or acid.

4.11. *Paint.* Paint used in coating the hydrant as required by Sec. 6.1 shall conform to the requirements of Federal Specification TT–V–51a asphalt varnish or Army-Navy Specification JAN–P–450. Exterior coating above the ground line (Sec. 6.2) shall conform to Federal Specification TT–P–86a (Type IV), *unless otherwise specified by the purchaser.*

Sec. 5—Design

5.1. *Iron and bronze—where used:*

5.1.1. *Parts of cast iron.* The parts where cast iron may be used are the footpiece or elbow, the barrel or standpipe, the frost jacket if used, the bonnet, the packing plate, the gates, the nozzle caps, and small miscellaneous parts where the use of cast iron will conform to good practice.

5.1.2. *Parts of bronze.* The parts where bronze is used are:

Parts	Refer to Sec.	Grade of Bronze
Drain valve parts	5.17	I, II, III, IV, VI
Glands	5.21	I, II, III, IV, VI
Gland bolts	5.21	II, III, IV
Gland bolt nuts	5.21	II, III, IV
Gland bushings	5.21	I
Nozzles	5.10	I
Stems or threaded portion of stems	5.15.1	II, III, IV, V
Stem nuts	5.15.1	I, II, III
Stuffing boxes	5.21	I
Stuffing box bolts and nuts	4.8.3	II, III, IV, V
Valve seats or valve seat rings	5.14	I, II, III, IV

Reference should be made to the sections of this document where the above components are detailed. In several instances, ferrous metal, properly treated, may be used instead of bronze.

5.2. *Size of hydrant valve.* The main valve opening shall be at least 4 in. in diameter for hydrants having two 2½-in. nozzles; at least 5 in. for hydrants having three 2½-in. nozzles; and at least 6 in. for hydrants having four 2½-in. nozzles. With other than circular seat rings, the area of the seat ring opening shall equal that of the above required circular seat ring. Any seat ring diameter offered other than those enumerated shall be considered equal to the next smaller size as specified above.

Combinations of nozzles other than those above are permissible, provided that the total potential discharge capacity of such nozzle combination connected to the main valve does not exceed the maximum discharge capacity

of nozzles connected to a main valve of the same size in the above list.

Thus, as it is understood that hose nozzles and pumper nozzles are not in action at the same time, one pumper nozzle may be added to any of the above hose nozzle combinations, or substituted for any one or two hose nozzles; provided that the discharge area of the pumper nozzle *either*: (a) does not exceed the discharge area of the 2½-in. hose nozzle or nozzles to which it is added or for which it is substituted, *or* (b) does not exceed the discharge area of the main valve of the hydrant.

5.3. *Valve facing.* The main valve of the hydrant shall be faced with a suitable yielding material, such as rubber, leather, balata, or composition, where it bears on metal seats. The material shall be clamped so that the valve will not leak at the stem. The bottom stem threads may be protected by a suitable cap nut.

5.4. *Hydrant barrel wall thickness.* The thickness of the wall of the barrel shall be not less than the thickness specified for Class 250 pit-cast cast-iron water pipe of like diameter produced in accordance with ASA A21.2 (American Standard Specifications for Cast Iron Pit Cast Pipe for Water or Other Liquids) and Table 2.3 thereof. The wall thickness of barrels of fractional-inch diameter shall be that for the next larger diameter listed below. The specified thicknesses thus are:

Barrel ID *in.*	Wall Thickness *in.*
5	0.42*
6	0.43
7	0.46*
8	0.50
9	0.56*
10	0.63

* Values not shown in Table 2.3 of ASA A21.2 but interpolated for purposes of these specifications.

Variations in thickness of walls of hydrant barrels shall not exceed those permitted for pit-cast cast-iron pipe of like diameter as recorded in Sec. 2–11 (b) of ASA A21.2, as follows:

Nominal Diameter *in.*	Tolerance *in.*
3–8 incl.	0.07
10–24 incl.	0.08

Tolerances 0.02 in. greater than those listed above shall be permissible over areas not exceeding 8 in. in length in any direction.

5.5. *Barrel sections.* If hydrants are made in two or more sections with a flange or other joint near the ground line, the joint shall, unless otherwise specified by the purchaser, be located at least 2 in. above the finished grade line.

5.6. *Waterway.* Changes in the shape or size of the waterway shall be accomplished by means of easy curves. The junctions of hose and pumper nozzles with the barrel shall be rounded to ample radii. Exclusive of the main valve opening, the net area of the waterway of the barrel and foot-piece at the smallest part shall be not less than 120 per cent of that of the net opening of the main valve.

5.7. *Friction losses.* With the hydrant 5 ft in length, measured from the bottom of the connecting pipe to the ground line, and discharging 250 gpm through each 2½-in. hose outlet, the friction loss shall not exceed the following:

Flow *gpm*	Pressure Loss *psi*
250	1
500	2
750	3
1,000	4

5.8. *Hydrant inlet.* The base of the hydrant, known as the footpiece or elbow, shall have a side or bottom inlet, provided with a bell, a flange, or other type of connection as specified or approved by the purchaser for connecting the hydrant to the branch from the main. The inlet shall be suitable for connection to pipe of not less than 6-in. nominal diameter, unless otherwise ordered. In a hydrant provided with bell type connections, the bell dimensions shall conform to those shown in Specifications for Special Castings—AWWA C100 (Class D). In a hydrant provided with flange type connections, the flange dimensions shall conform to ASA B16.1 (Cast Iron Pipe Flanges and Flanged Fittings, Class 125).

5.9. *Lugs.* Lugs, if required, for harnessing the hydrant to the connecting pipe from the street main shall be provided on the bell of the elbow.

5.10. *Joining nozzles to barrel.* Hose nozzles shall be of Grade I bronze and shall be fastened into the barrel by a fine thread or by leading. If lead is used, an adequate recess shall be provided for the lead. All nozzles shall be safeguarded against blowing out. For screwed-in nozzles, a pin or other approved method shall be employed to prevent the nozzle from turning or backing out.

5.11. *Nozzle caps.* Nozzle caps shall be of cast iron and shall be provided for all outlets. The threads shall conform to those of the nozzle. The cap nut shall have dimensions similar to those of the operating nut. Unless otherwise ordered, caps shall be securely chained to the barrel with a metal chain having links made from stock not less than $\frac{1}{8}$ in. in diameter, or of equivalent cross-sectional area. A recess shall be provided at the inner end of the threads to retain a gasket.

5.12. *Valves readily removable.* The hydrant shall be so designed that, when it is in place, no excavation will be required to remove the main valve and the movable parts of the drain valve.

5.13. *Main valve remains closed after accident.* The barrel and operating mechanism shall be so designed that, in the event of accident, damage, or breaking of the hydrant above or near the grade level, the main valve will remain closed and reasonably tight against leakage.

5.14. *Valve seats.* Valve seats or seat rings shall be made of Grade I, II, III, or IV bronze.

5.15. *Operating mechanism:*

5.15.1. The operating threads of the hydrant shall be so designed as to avoid the working of any iron or steel parts against either iron or steel. Either the operating stem or its threaded stem nut (or sleeve) shall be of noncorrodible metal. If the threaded portion of the operating stem is bronze, it shall be made of Grade II, III, or IV material. If the threaded stem nut is bronze, it shall be made of Grade I, II, or III material. The operating stem and nut shall have square, V, or Acme threads. The design factor of safety of the operating mechanism shall be five, and shall be based on the foot-pounds torque required for the closing and opening of the individual hydrant at 150-psi working water pressure. Hydrants shall be capable of being opened or closed after being subjected to an operating torque of 200 ft-lb applied at the operating nut. The torque requirements apply only to hydrants of 5-ft bury and under. (See Foreword.)

5.15.2. The operating mechanism, particularly the lead of the thread of

the operating stem, shall be so designed that when the operating nut is turned at the fastest possible rate using a 15-in. wrench to shut off the flow of water, the resulting pressure in the system shall not exceed twice the static pressure if the static pressure averages 60 psi or greater. If the static pressure averages less than 60 psi, the pressure shall not be raised more than 60 psi above the static.

NOTE: As the number of complete turns of the hydrant wrench required to close the hydrant valve has a bearing upon the possibility of developing water hammer, preference is indicated for lead of the threads on the hydrant stem which requires *not less than:* 8 complete turns to close a 4-in. hydrant; 10 complete turns to close a 5-in. hydrant; and 12 complete turns to close a 6-in. hydrant.

5.16. *Drain or waste outlet.* An outlet for drainage shall be provided in the base or barrel, or between the base and barrel, of the hydrant. It shall be made of Grade I, II, III, or IV bronze (or other corrosion-resistant metal) or bushed therewith completely from the valve to the outside.

5.17. *Drain valve mechanism.* A positive-operating noncorrodible drain valve or valves shall be provided to drain the hydrant properly by opening as soon as the main valve is closed, and to close tightly when the main valve is opened. The seat of the drain valve shall be made of Grade I, II, III, IV, or VI bronze or other noncorrodible material and shall be fastened securely in the hydrant.

5.18. *Hydrant top.* The hydrant top or bonnet shall be of cast iron, and shall be free-draining and of a type that will maintain the operating mechanism in readiness to use under freezing conditions. It shall be so designed as to make tampering difficult and shall be provided with convenient means to afford lubrication to insure ease of operation and the prevention of wear and corrosion.

5.19. *Operating and cap nuts.* The operating nut and the cap nuts on the hose and pumper nozzles shall conform to those in service in the system where the hydrant is to be installed. Unless otherwise required, the nuts shall be of pentagonal shape. The pentagon shall measure $1\frac{1}{2}$ in. from point to flat at the base of the nut and $1\frac{7}{16}$ in. at the top. Faces shall be tapered uniformly, and the height of the nut shall be not less than 1 in. The point-to-flat dimension shall be measured to the theoretical point where the faces would intersect were there no rounding off of the corner. Wrenches for these nuts shall have no taper in the openings, so as to be readily reversible.

5.20. *Direction of opening.* The direction of rotation of the operating nut to open the hydrant should conform to the practice in the water system where the hydrant is to be installed. *Unless otherwise ordered* by the purchaser, the hydrant shall be opened by turning the operating nut *counterclockwise.* An arrow and the word "Open" shall be cast in relief, so as to be clearly visible, on the top of the hydrant to designate the direction of opening.

5.21. *Stuffing boxes.* Stuffing boxes shall be made of Grade I bronze or cast iron. The width of the packing shall be at least $\frac{1}{4}$ in., and the depth of packing space shall be at least four times its width. Glands shall be made of solid bronze or bronze-bushed cast iron. They shall be properly secured to prevent rotation with the operating nut. Gland bolts or studs shall be made of either Grade II, III, or IV bronze or rustproofed steel. They

shall be of not less than $\frac{3}{8}$-in. diameter if bronze, or not less than $\frac{1}{2}$-in. diameter if steel.

Sec. 6—Painting and Marking

6.1. *Coating.* All iron parts of the hydrant, inside and outside, shall be thoroughly cleaned and thereafter, *unless otherwise stipulated,* all surfaces inside and outside (except the exterior portion above the ground line) shall be coated with asphalt varnish (Sec. 4.11). They shall be covered with two coats, the first being allowed to dry thoroughly before the second is applied.

6.2. *Shop coating above ground line.* The outside of the hydrant above the finished ground line shall be thoroughly cleaned and thereafter painted in the shop with two coats of paint of a durable and weatherproof composition (Sec. 4.11) which shall produce a surface to which later coats of paint having a linseed oil or other approved base will readily adhere. The color or colors to be used shall be as specified by the purchaser.

6.3. *Marking.* All hydrants shall have permanent markings identifying the manufacturer by name, initials, or abbreviations in common usage, and designating the size of the main valve opening and the year of manufacture. Markings shall be so placed as to be readily discernible and legible after hydrants have been installed.

Sec. 7—Workmanship

7.1. All foundry and machine work shall be done in accordance with standard good practice for the class of work involved; in conformance with approved drawings, if required; and as approved by the inspector representing the purchaser. When assembled, hydrants manufactured in accordance with these specifications shall be well fitted, smooth operating, and watertight.

7.2. All parts shall conform to the required dimensions and shall be free from defects which will prevent proper functioning of the hydrant.

7.3. All machined parts shall be made to template or gage.

7.4. All joints shall be faced true and shall be watertight when subjected to the water pressure for which the hydrant is designed.

7.5. All iron parts receiving bronze mounting shall be made true and smooth, and the bronze mounting shall be finished to fit.

7.6. All castings shall be clean and sound, without defects which will impair their service. No plugging, welding, or repairing of such defects will be allowed.

7.7. All like parts of hydrants of the same model and size produced by the same manufacturer shall be interchangeable.

Sec. 8—Hydrostatic Test

Hydrants for a working pressure of 150 psi or less shall be subjected, after assembly, to two shop tests under a hydraulic pressure of 300 psi. One test shall be made with the whole interior of the hydrant under pressure; and another with the main valve closed and the footpiece under pressure from the inlet side. Under the above test procedure, there shall be no leakage through the main valve, drain valve, or stuffing box, nor through the castings or the joints of the assembled hydrant. Leakage or other imperfections found in either test shall be corrected before the hydrant is accepted.

Sec. 9—Inspection

9.1. All work under these specifications shall be subject to inspection and

approval by the purchaser's duly authorized engineer or inspector, who shall at all times have access to all places of manufacture where materials are being produced or fabricated or where tests are being conducted, and who shall be accorded full facilities for inspection and observation of tests. Any hydrant or part which he may condemn as not conforming to the requirements of these specifications shall be made satisfactory or shall be rejected and replaced.

9.2. If the purchaser has no inspector at the plant, the manufacturer shall, if so requested at the time the order is placed, certify that the required tests on the various materials and on the completed hydrant have been made, and that the results of all tests conform to the requirements of these specifications.

Sec. 10—Preparation for Shipment

Hydrants shall be complete in all details when shipped. The manufacturer shall use due and customary care in preparing them for shipment, so that no damage due to the manufacturer's negligence will occur in handling or in transit. Hydrants must be drained and completely closed before shipment.

APPENDIX

Characteristics of National Standard Fire-Hose Coupling Screw Thread

Basic dimensions of National (American) Standard hose coupling screw threads are shown in the following tabulation. The complete document (ASA B26) may be obtained at a price of 30 cents per copy from the American Society of Mechanical Engineers, 29 West 39th Street, New York.

1	Nominal inside diameter of hose coupling	2½	3	3½	4½
2	Number of threads per inch	7½	6	6	4
3	Total length of threaded part of coupling and hydrant nipple, external thread	1	1⅛	1⅛	1¼
4	Distance from face of nipple to start of second turn	¼	5/16	5/16	7/16
5	Depth of coupling swivel to washer seat	13/16	1 1/16	1 1/16	1 9/16
6	Distance from face of coupling swivel to start of second turn	3/16	¼	¼	⅜
7	Depth of thread of coupling swivel	11/16	13/16	13/16	1⅛

All dimensions given in inches.

Outer ends of external and internal thread should be terminated by the "Higbee Cut" on *full thread* to avoid crossing and mutilation of thread.

Specifications for

Uniform Marking of Fire Hydrants

The American Water Works Association, recognizing that the adoption of a capacity marking scheme by any water department is optional, herewith provides the following uniform color scheme for painting hydrants rated in terms of their relative capacity.

1. Hydrants are classified as follows:

Class A: Hydrants that on individual test usually have a flow capacity of 1,000 gpm or greater.

Class B: Hydrants that on individual test usually have a flow capacity of 500 to 1,000 gpm.

Class C: Hydrants that on individual test usually have a flow capacity of less than 500 gpm.

Capacities are to be rated by flow measurements of individual hydrants at a period of ordinary demand. When initial pressures are over 40 psi at the hydrant under test, the rating is to be based upon 20-psi residual pressure, observed at the nearest hydrant, connected to the same main, from which no water is being drawn. When initial pressures are less than 40 psi, residual pressures shall be at least half of the initial.

2. The following is the capacity-indicating color scheme:

2.1. *Public hydrants.* All barrels are to be painted chrome yellow except in cases where another color is desired. The tops and nozzle caps of the classes as outlined in Sec. 1 are to be painted as follows:

Class A—green
Class B—orange
Class C—red

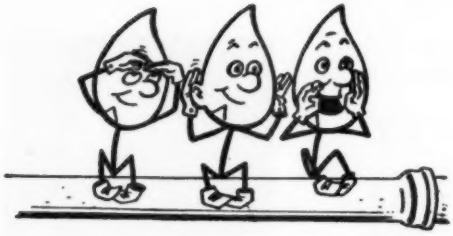
2.2. *Private hydrants.* Within private enclosures, the marking is to be at the discretion of the owners. When in public streets, they should be painted to distinguish them from public hydrants.

3. All location markers for flush hydrants should carry the same color background as stated above for class indication, with such data stenciled or painted thereon as may be deemed necessary.

4. The colors shall signify only the approximate capacity of the individual hydrant as tested alone and not its capacity when more than one hydrant in the vicinity is in use. The marking of the hydrant is not to be considered as in any way guaranteeing the capacity indicated by the color.

NOTE: These specifications were adopted by the American Water Works Association at its 1937 Convention at Buffalo and were originally published in the April 1937 JOURNAL, p. 449.

The standard color scheme duplicates, in essentials, similar plans adopted by the Maine Water Utilities Assn. in 1929, by the New England Water Works Assn. on Mar. 21, 1934, and by the National Fire Protection Assn. on May 14, 1936.



Percolation and Runoff

Grand Rapids may have sped by by the time this issue appears, all too fast for our reporting. Not so fast, though, that we haven't been able to prepare our congratulations to all of AWWA on a whole host of new convention records and on this new roster of officers and directors:

President—Morrison B. Cunningham, superintendent and engineer, Water Dept., Oklahoma City, Okla. (*see* frontispiece, facing p. 443). Born in Greenville, Tex., in 1896, Cunningham served in the Navy during World War I and joined the Oklahoma City department in 1919, first as superintendent of construction, then, the following year, as distribution system superintendent. In 1922 he was appointed assistant superintendent and engineer, and after ten years in this position became assistant and then acting city manager. He was appointed to his present post in 1937.

An AWWA member since 1930, he became a member of the old Southwest Water Works Assn. in 1921. He became vice-chairman of its successor, the Southwest Section of AWWA, in 1939 and served as its chairman the following year. In 1948 he became the section's national director for a three-year term, and received its Fuller Award in 1949. He has also been an officer of AWWA's Water Works Management Div., chairman of the Committee on Radio and Mobile Communication Facilities for Water Works, and a member of the Committee on Water Works Administration and the Task Group on Erosion Control of the Committee on Watershed Protection and Maintenance. He is AWWA representative on the National Committee for Utilities Radio. Other technical societies in which he is active include the Oklahoma Society of Professional Engineers and the Engineering Club of Oklahoma, both of which he served as president and member of the Board of Directors; the Engineers Joint Council; and the Federation of Sewage and Industrial Wastes Associations. He has also been a member of the Governor's Board on Stream Pollution, the Engineers' Advisory Board for State Planning and Resources, and the Board of Interstate Compacts.

Vice-President—Dale L. Maffitt, general manager, Des Moines, Iowa, Water Works. Born in Des Moines in 1892, and recipient of a B.S. degree from Drake University in 1914, he joined the Des Moines Water Works

(Continued on page 34 P&R)

(Continued from page 33 P&R)

Vice-President—
Dale L. Maffitt

Treasurer—
William W. Brush

upon his graduation and served as assistant chemist. In 1916 he was made chief chemist, and in the course of the next ten years at this occupation he also found time to undertake graduate work in chemistry and chemical engineering at Massachusetts Inst. of Technology. The next steps up the ladder were his appointment in 1926 to be assistant to the general manager, and finally, in 1933, promotion to the post of general manager.

An AWWA member since 1918, Maffitt's extensive activities have made him chairman of the old Missouri Valley Section, and twice director for the Iowa Section, which gave him the Fuller Award in 1949. At the time of his election, in addition to serving as his section's director, he answered to the titles of: chairman of the Water Resources Div. (of which he has previously been director and vice-chairman), chairman of the Committee on Public and Worker Relationships, chairman of the Committee on Pension and Retirement Plans, and, finally, member of the following committees and task groups—Water Works Administration, Program, Safety Practices in Distribution, and Water Use in Fire Prevention and Protection. Previous activities include the chairmanship of the old Finance and Accounting Div., of the Fuller Award Society, and of the Committee on Social Security Legislation; plus membership in committees on Water Works Practice, Survival and Retirement Experience With Water Works Facilities, and Federal Activities.

Treasurer—William W. Brush, editor of *Water Works Engineering*. Brush was born in Orange, N.J., in 1874 and was educated at New York Univ., from which he received B.S., C.E., and M.S. degrees. He served as engineer with the Brooklyn Water Dept., from 1894 to 1907, transferring

(Continued on page 36 P&R)

SMOOTH Coordination

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(Continued from page 34 P&R)

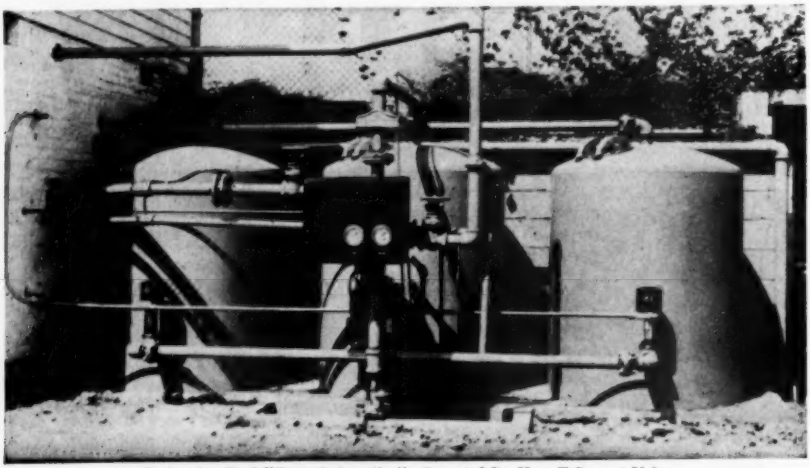
to the New York Board of Water Supply in the latter year. In 1910, he was shifted to the city's operating division, the Dept. of Water Supply, Gas, and Electricity, as deputy chief engineer of water supply. In 1927 he was appointed chief engineer of water supply, and served in that capacity until 1934, when he retired after a cumulative total with the three organizations of 40 years of service. He then began his present affiliation with the Case-Shepperd-Mann Publishing Corp as editor of *Water Works Engineering*.

His reelection as treasurer continues an unbroken record of 31 years of high office in the Association, for, except for a two-year interval in 1928–29 when he was successively vice-president and president, Brush has been holding AWWA's purse-strings since 1922. In that time also he has been active on many committees, and has served ex officio as a member of both the Board of Directors and its Executive Committee. He received the John M. Diven Medal in 1932 and in 1937 was made an Honorary Member.

SECTION DIRECTORS

Alabama–Mississippi—Tip Henry Allen, general superintendent, Canton, Miss., Municipal Utilities. Born in Canton in 1899 and educated there, he took correspondence courses in steam and electric engineering. In 1922 he was steam plant operator for Canton, and a year later joined the Arkansas Utilities as water meter superintendent. Returning to Canton as assistant superintendent, he held that post for 17 years, until being promoted to his pres-

(Continued on page 38 P&R)



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Automatic operation of swimming pool filters adds **very little** to their overall cost . . . saves plenty on operation. The above shows 3 H & T swimming pool filters **automatically** operated by an electrically operated **H & T** poppet type multiport valve.

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The Smith Protectop Hydrant is designed to permit rapid return to service at minimum cost when a Hydrant is damaged as a result of a traffic accident.

The Protectop Hydrant Standpipe and Valve Stem are equipped with Special Couplings located just above the ground. The Couplings withstand operating pressures and ordinary impact with an ample factor of safety. Under excessive impact occasioned by traffic accidents the Couplings fracture at the design points thus minimizing the damage and permitting speedy return to service at low cost.

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Write for details.

38

FIRE HYDRANTS · VALVES SINCE 1836

THE A.P. SMITH MFG. CO.

EAST ORANGE, NEW JERSEY

(Continued from page 36 P&R)

Ala.-Miss.—Allen

Arizona—Baker

California—Grayson

ent post in 1940. He has held the successive posts of vice chairman and chairman of his section.

Arizona—R. Gail Baker, city engineer, Phoenix. Born in Phoenix in 1897, he attended the University of Arizona and Massachusetts Inst. of Technology, obtaining a C.E. degree from the former institution in 1927. After a brief period of service in World War I, he served as a draftsman and transitman, and in various other capacities. In 1921 he joined the Salt River Valley Water Users Assn., working his way up to the post of superintendent of irrigation and chief hydraulic engineer. He left in 1934 for a number of engineering and consulting operations, including that of consultant for the state of Arizona in making cooperative studies of the Colorado River with the Bureau of Reclamation. In 1946 he returned to the city of Phoenix, which he had served some years earlier as city engineer and water superintendent, to resume the post of city engineer.

California—Lauren W. Grayson, chief engineer and general manager, Public Service Dept., Glendale. Born in Boone, Iowa, in 1907, he joined the engineering staffs of the Riverside, Calif., Dept. of Public Utilities in 1926, and was advanced over the years until he became general manager in 1942. He came to Glendale to head its Public Service Dept. in 1951.

A past chairman of the California Section, Grayson has also been a member of its Executive Committee. In the national Association, he has been a director of the Water Works Management Div., a member of the committee that organized the Water Resources Div., and, in 1950, its chairman. He is affiliated with several other professional and technical organizations, and has been vice-president of the California Municipal Utilities Assn.

Iowa—John W. Pray, manager, Dept. of Municipal Utilities, Fort Dodge. Born in 1886 in Fort Dodge, and educated there, he joined the city's water department in 1903 and was made superintendent of the water and sewer system in 1909. In 1916 the operation of the community's hydroelectric plant was added to his responsibilities, and in 1938 he took charge of the sewage treatment plant which he

(Continued on page 40 P&R)

just a reminder that -

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(POWDER)

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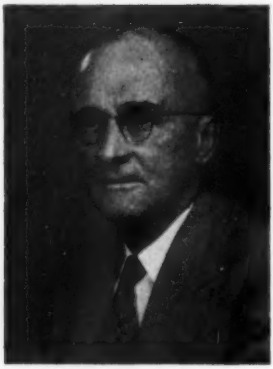
HYDRAULIC DEVELOPMENT CORPORATION

(Continued from page 38 P&R)

Iowa—Pray

Ky.-Tenn.—Bagwell



Michigan—Ayres

had helped to design and construct. In that year also his title was changed to manager of municipal utilities.

A Life Member of AWWA, Pray had been chairman of the old Missouri Valley Section and had received its Fuller Award. He was also made chairman of the Iowa Section upon its organization in 1946.

Kentucky-Tennessee—Charles H. Bagwell, business manager, Bureau of Water, Knoxville, Tenn., Utilities Board. He attended Hiawassee College, Madisonville, Tenn., from which he was graduated in 1931. In 1940 he joined the Engineering Dept. of the Knoxville Utilities Board, becoming superintendent of meter maintenance and installation two years later. He was appointed to his present post in 1950.

Bagwell has successively been trustee, vice-chairman, and chairman of the Kentucky-Tennessee Section.

Michigan—Louis E. Ayres, consultant with the firm of Ayres, Lewis, Norris, and May, Ann Arbor. Born in Port Austin, Mich., in 1886, Ayres attended the University of Michigan, from which he received the B.S. degree in civil engineering in 1908. From 1908 almost continuously until 1923, he was associated with the late Gardner S. Williams on water power and water supply projects. In the latter year he began the association with the firm that bears his name, and he has numbered among his clients such organizations as the city of Detroit and the Tennessee Valley Authority.

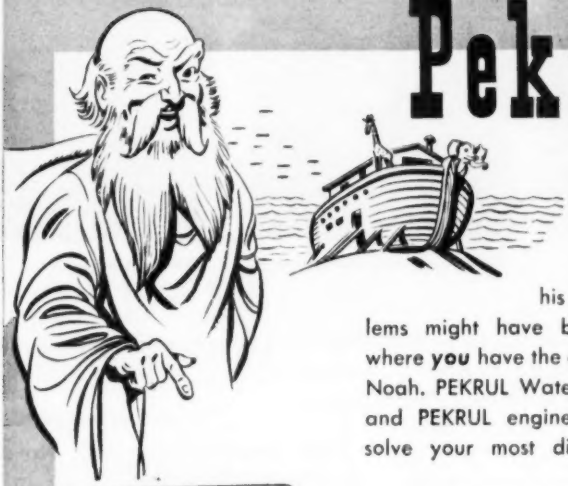
Ayres' varied activities in AWWA have brought him the distinctions of Life Membership and his section's Fuller Award. In addition, he has served as vice-chairman and chairman of the section, done distinguished and fruitful work as chairman of both sectional and national committees on water rates, and been a member of the Committee on Water Works Administration. He belongs to many professional and technical organizations and has been director of the American Society of Civil Engineers and president of the Michigan Engineering Society.

Nebraska—Ralph H. Lancaster, superintendent of public works, Kearney, where he was born in 1902. He was educated at Kearney State College

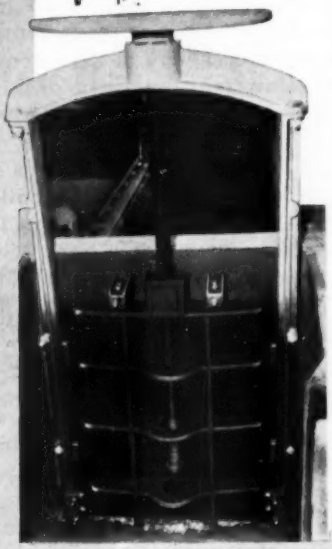
(Continued on page 42 P&R)

If Noah had known about...

Pekrul Gates



his water control problems might have been easier. There's where **you** have the advantage over poor Noah. PEKRUL Water Control Equipment and PEKRUL engineers stand ready to solve your most difficult requirements.



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Write for Catalog 49

MORSE BROS. MACHINERY
DENVER, COLORADO

(Continued from page 40 P&R)

Nebraska—Lancaster

New England—Stradling

New Jersey—Norcom

and the University of Nebraska, and until 1941 was engaged in the oil business. In that year he became Kearney's superintendent of public works, the post he has continued to hold until now. In addition to his activities in AWWA which previously brought him election to the chairmanship of his section, he has been active in community affairs and was chairman for a while of the Utility Section, Nebraska League of Municipalities.

New England—Fred P. Stradling, manager, Bristol County, R.I., Water Co. Born in Muncie, Ind., in 1897, he received his education from schools there and from the Muncie Normal Institute. After a start in the newspaper business, he joined the Muncie Water Works Co. in 1918 as cashier, and two years later transferred to the Kokomo, Ind., Water Works Co., of which he became manager four years later. In 1941 he became vice-president and assistant to the president of American Water Works & Electric Co., New York, helping to manage thirteen water utilities in seven states. In 1943 he became assistant manager of the East St. Louis, Ill., & Interurban Water Co., and in 1947 assumed his present position. He was chairman, while in Indiana in 1933, of the local AWWA section.

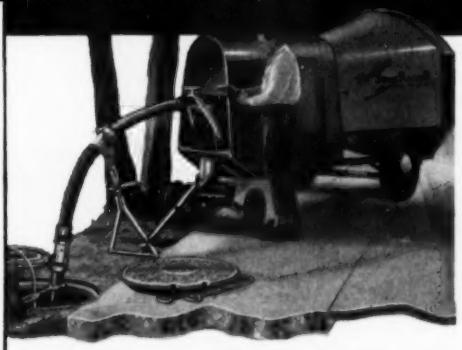
New Jersey—George D. Norcom, consultant, Red Bank. Born in Sea Isle, N.J., in 1892, he received the B.S. degree in chemistry in 1915 from Rutgers University, and in 1923 was also awarded the sanitary engineering degree. He entered the service of the New Jersey Dept. of Health as a chemist in 1916, and shortly afterward went to Washington, D. C., as an assistant chemist in the filtration plant. Service with the Sanitary Corps in World War I interrupted his career, and he returned to join the Pittsburgh Testing Laboratory. In 1921 he became sanitary engineer for Wilmington, N.C., and five years later moved to Charlotte as superintendent of filtration. He joined the Federal Water Service Corp. in 1928 as a sanitary engineer and chemist, leaving that firm in 1933 to establish his own consulting firm, first in New York, later in Red Bank.

A Life Member of AWWA, Norcom has headed the Water Purification Div. and the National Coordinating

(Continued on page 44 P&R)

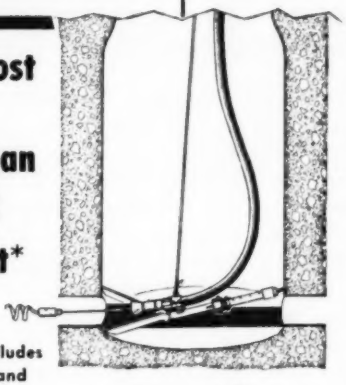
DO YOU REALIZE ? ONE "FLEXIBLE" SEWERODER

CLEANS 50 BLOCKS OF SEWERS PER WEEK!



At a Cost of Less Than 2¢ a Foot*

*This figure includes maintenance and parts replacement.



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—Is a mechanical marvel that does all rodding with two men — eliminating 9/10ths of the usual hard labor in a day's work. It's increased, low cost capacity permits "preventative maintenance" to be carried on inexpensively —and eliminates costly emergency work. Rod reel contains 900 feet of rods for instant use. Imparts a rotating action to rods and tools. Truck mount models also available.

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AMERICA'S LARGEST MANUFACTURER OF PIPE CLEANING TOOLS AND EQUIPMENT

(Continued from page 42 P&R)

Committee. He has also served on the Committee on Procedure for Disinfecting Water Mains and helped to revise the AWWA manual, *Water Quality and Treatment.* In addition, he is co-author with Kenneth Brown of the book *Water Purification for Plant Operators.* He has been especially active in the New Jersey section, having served as trustee, vice-chairman, and chairman; and heading or working for a variety of section committees.

New York—Harding

New York—James C. Harding, commissioner of public works, Westchester County, White Plains. Born in Pittsfield, Mass., in 1900, Harding went to work for the consulting firm of Fuller and McClintock in 1920 as assistant engineer. In 1927 he opened his own consulting office, closing it in 1942 to accept the post he still holds. Harding has been chairman of the Committee on Deep Wells since its organization in 1940, and in 1946 the Diven Medal was awarded to him for the successful completion of the deep well standards. He has also been chairman of the New York Section's Water Resources Committee. Other organizations to which he belongs include the State Comptroller's Committee on Water Distribution, American Geophysical Union, American Public Works Assn., American Society of Civil Engineers, Federation of Sewage and Industrial Wastes Associations, and New York State Society of Professional Engineers.

Pacific Northwest—Charles C. Casad, superintendent, Water Dept., Bremerton, Wash. Born in Seattle in 1889, he moved to Bremerton early and was working for the city while still in high school. He attended Washington State College, majoring in civil engineering, and was graduated in 1915. For a year, following an interest developed in school, he played professional baseball, but he soon returned to the

(Continued on page 46 P&R)

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Flexible **CARLON** plastic pipe is furnished in lengths up to 400 feet and requires fewer fittings. Permanent installations can be made in only a fraction of the time required for metal pipe.

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(Continued from page 44 P&R)

Pacific Northwest—Casad

Pennsylvania—Morgan

Manufacturer—Jones

Bremerton engineer's office, and by 1921 had become city engineer. In 1924 he was elected commmissioner of public works, and he held this post until 1942, when he relinquished his other duties to become superintendent of water. He is active in community affairs and holds membership in the Seattle Engineers' Club. In 1943 he received his section's Fuller Award.

Pennsylvania—L. S. Morgan, division engineer, Mine Wastes Div., Bureau of San. Eng., State Dept. of Health, Greensburg. Born in 1899 in Wilkes-Barre, Pa., he attended Pennsylvania State College and obtained the B.S. degree in sanitary engineering in 1922. He joined the State Dept. of Health at Harrisburg as a sanitary engineering assistant upon leaving school, shortly afterwards accepting the post of engineer in charge of the Schuylkill River survey for the Philadelphia Bureau of Water. Returning to the State Dept. of Health in 1925, he served as assistant sanitary engineer, district engineer, and finally division engineer, his present post, in statewide charge of mine drainage.

Morgan served the old Western Pensylvania Section as trustee, vice-chairman, chairman, and secretary-treasurer; and he has also held the latter post in the Pennsylvania Section since its organization. In 1949, his activities were rewarded with the Fuller Award. He has also been president of the Pennsylvania Water Works Operators' Assn.

Manufacturer—Everett M. Jones, vice-president, Simplex Valve & Meter Co., Philadelphia, Pa. Born in 1908 in Philadelphia and educated at Lehigh University and Worcester Polytechnic Inst., he joined the Simplex organization in 1929 as a sales trainee and advanced rapidly, becoming sales manager in 1935. By 1942 he had become general manager, and five years later he was elected to the vice-presidency of the firm. A member of the Water & Sewage Works Manufacturers Assn., which he represents on the AWWA board, he has twice—in 1945 and in 1952—been its president.

Herman E. Trotter has been appointed to represent B-I-F Industries in the Buffalo, N. Y., area, with headquarters at 3053 Main St. He will handle sales of products of Builders-Providence, Inc., and Omega Machine Co.

(Continued on page 48 P&R)

FIRST ...to

PRESENT THESE METER SERVICING CONVENIENCES

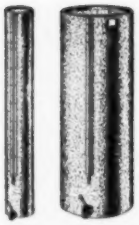
Ford developments and inventions are characterized by their ingenious and practical approach to difficult problems in the setting and testing of water meters. Here are shown but a few of FORD'S FIRSTS . . . each a pioneering achievement still extensively used and imitated. Refer your problems to FORD FIRST.

LIFTER WORM LOCK

The original Ford Worm Lock was introduced almost forty years ago. Because of its simplicity, safety and powerful screw-jack action it is now widely used. The Lifter feature, a recent improvement, provides automatic attachment of the key on unlocking.

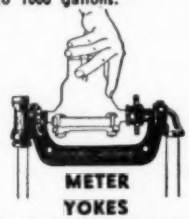
The **COPPERHORN**

The Copperhorn makes an ideal meter setting in most basements. It provides an all-copper waterway and physical support for customer piping. Frequently it saves more than its cost in pipe fittings and meter couplings eliminated. Simple and easy to install, it is a beautiful example of ingenious, functional design.



CALIBRATED TESTING TANKS

Before Ford Calibrated Testing Tanks were put on the market about 35 years ago, such meters as were tested were checked against gravimetric scales, which were complicated and inconvenient. Thousands of Ford Tanks are in service, in sizes from one to 1000 gallons.



METER YOKES

The Ford Yoke dates back to 1911. Its outstanding success resulted in a wide variety of meter holding devices called yokes. But the Ford Yoke as now made offers advantages not obtainable in any other type of meter setting. Millions are in use.

METER VALVE

The Meter Valve is a close-coupled combination of an inverted key valve and a meter connection. It saves material, pipe joints and space in the meter setting. Ford Meter Valves bear the trademark name of Ringstyle Valves.

THE FORD METER BOX COMPANY, INC.

FOR BETTER WATER SERVICES

Wabash, Indiana

FORD

(Continued from page 46 P&R)

In Rio they do as the Romans did, though less indiscriminately and providing their own towels—use the baths, that is, as an instrument of sociality. Cause of this recent revival of really public health is nothing more than a distribution system that delivers only about 60 per cent of its intake from a supply that is inadequate in the first place. Thus, Rioans lucky enough to live in relatively well-watered areas have taken to inviting less fortunate friends in for a bath. And, during the torrid Brazilian summers, the social life, thereby, virtually buds in suds.

In the U.S., meanwhile, it is the primarily antisocial aspects of bathing that have come in for comment. Thus, an Emory University medical professor recently rated headlines with a statement that "present-day bath methods and manners are such as to take us away from the physical and spiritual comforts of the lazy, timeless, restful immersion of our bodies in tubs of warm water." Fortunately, Emory is in Georgia rather than Texas or the good doctor might have been burned for calling for bigger, better, and longer baths "with more time for reading, relaxing, and singing." Texas these days is sort of like Rio for a different reason and with everyone waiting to be invited.

It is in the austere isles of Britain, though, that social, physical, and spiritual all appear to suffer. There, the technical journal, *Research,* has reported, from results of a recent governement survey, that few Britons take more than two baths per week and "most limit themselves to a once weekly immersion on Friday or Saturday," while "Scotland reveals itself as being the least bath-loving section with 13 per cent of the 83 persons interviewed taking less than one bath a week in winter." All of which would seem to indicate that the Order of the Bath had been unenforceable.

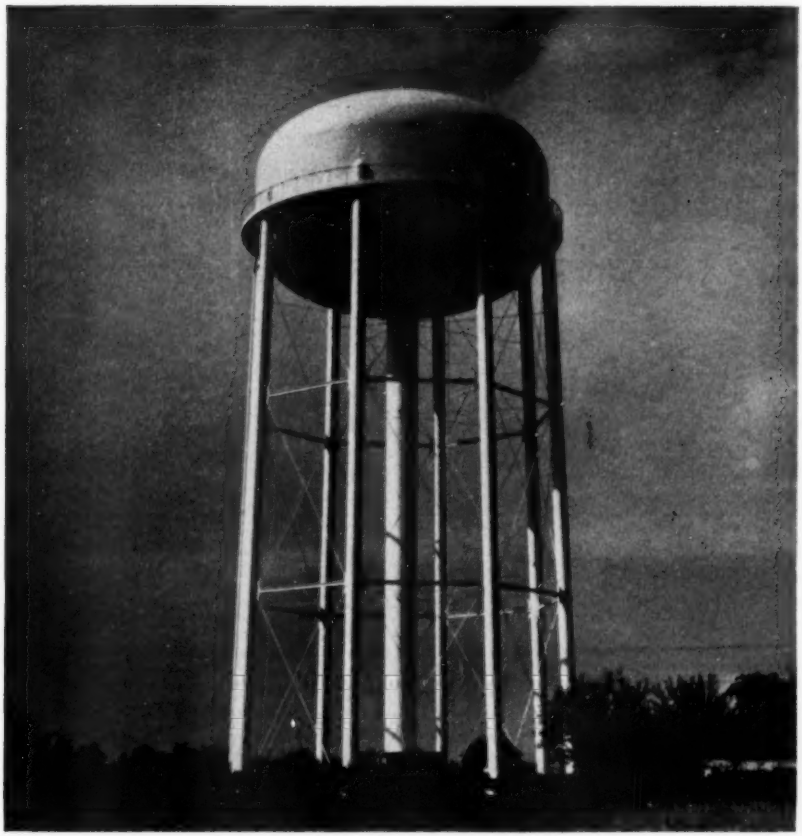
If all this sounds rather like a water works man's Kinsey Report, perhaps that wouldn't be a bad idea.

M. J. Shelton, general manager and chief engineer of the La Mesa, Lemon Grove, and Spring Valley Irrigation Dist., has been named by California's Gov. Earl Warren to serve as a member of the State Water Pollution Control Board. He is replacing G. E. Arnold, who resigned last fall to come to Philadelphia (see September 1952 JOURNAL, P&R p. 8). In order to give full attention to his new duties, Shelton is resigning from the San Diego Water Pollution Control Board, of which he has been chairman since the state pollution control program was begun in 1950. Paul Beerman, director of the San Diego Water Dept., has been appointed by Gov. Warren to replace Shelton on the San Diego board.

J. Leslie Hart, western sales manager of U.S. Pipe & Foundry Co., has been appointed eastern sales manager, and will move from Chicago to company headquarters at Burlington, N.J., by July 1. Like his predecessor at Chicago, Carl N. Brown, who is now pipe sales manager of the company, Hart has been secretary-treasurer of the Illinois Section and will have to relinquish that post to come East. He will be replaced as western sales manager by P. King Farrington, now assistant Pacific Coast sales manager.

Henry Moretty, superintendent of the Parkrose, Ore., Water Dist. for the past seven years, has joined Neptune Meter Co. as Oregon representative, with headquarters at Portland.

(Continued on page 50 P&R)



McPherson Looks Ahead with a Horton Tank

Extensive municipal improvements in McPherson, Kansas, included over 15,000 ft. of water transmission lines and the modern Horton elevated water tank illustrated above. These additions will have a favorable effect on the city's water service for years to come.

Horton elevated water tanks with ellipsoidal bottoms are built in capacities from 15,000 to 500,000 gals. The radial-cone design is used for capacities from 500,000 to 3,000,000 gals.

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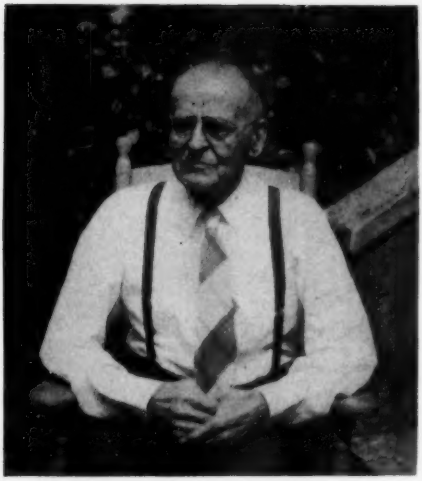
In Canada—HORTON STEEL WORKS, LIMITED, FORT ERIE, ONTARIO

(*Continued from page 48 P&R*)



Emiel A. Croll, AWWA's senior member, died at his home in Orlando, Fla., on March 3 after a long illness. At one time water works superintendent at Iron Mountain, Mich., he came to Florida on his retirement in 1926. His passing marks the end of an era in AWWA history, for only a few Associate Members can boast longer membership, and no individual could match Croll's record of affiliation. He joined AWWA on September 5, 1893, as one of fourteen applicants elected to membership at the opening of the annual conference at Milwaukee. A glance at the *Proceedings* for that meeting brings to light a quotation that needs only a few changes of name and place to be pertinent now:

> No doubt you are all familiar [said W. L. Cameron of Kansas City, Mo.] with the fact that thirteen years ago a few men (I believe fourteen or fifteen gentlemen [actually 22—ED.]) met in St. Louis, and from this small beginning has arisen this magnificent Association. I believe that Mr. Decker, with a few others perhaps, is the only one now left of those who attended that meeting in St. Louis. Most of the balance have gone to join the "Grand Association," from which, they say, there are to be no resignations or suspensions. . . .

John F. Skinner, consulting engineer, died on March 13 in Glendale, Calif. Before coming to Southern California in 1934, he had served as city engineer for Rochester, N.Y., for more than 40 years. He answered the demands of two military emergencies in the course of his career, serving in the Construction Div. of the Army during World War I, and, in collaboration with the firm of Holmes and Narver, engineering water and sewage works for military installations in the United States and Hawaii during World War II.

(*Continued on page 90 P&R*)

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Correspondence

SEDBL

Principally because of the very nominal entrance fee, I wish to submit my formal application as a charter member of the Society for the Elimination of the Dear in Business Letters [see March JOURNAL, p. 50 P&R], and will appreciate receiving my engraved membership card, or certificate, at your convenience.

Like Mr. Alderman, I also tried omitting both the salutation and the complimentary closing, a number of years ago, and, like him, finally bowed to custom. Although the recipients of such letters were kind enough to withhold any comments, I distinctly noticed the "lifted eyebrows" on one or two of my friends to whom I showed a copy of one of these letters. In addition, I noted that one or two prospective clients who had received a formal proposal written in this style retained another engineer. Believing that the main reason was my failure to begin with "The Honorable City Council," etc., and close with "Respectfully submitted," I finally returned to the use of "Gentlemen" as a salutation (although the designation was not at all times strictly applicable, either as to meaning or plural usage), and used a one-word complimentary closing of either "Sincerely" or "Respectfully." I still refused, however, to use the word "Dear" or to add the phrase, "I am, Your obedient servant."

Late in 1952, I received considerable encouragement by noting that the National Office Management Assn. advocates the use of a simplified form for business letters in which both the salutation and complimentary closing are dispensed with. So, as of January 1953, I have again thrown custom overboard. Although the exact form and style is still subject to experiment, it is hoped that you will soon appoint a Special Research Committee that will undertake the publication of a style manual that will serve until future generations discover the right method.

ROBERT L. STREETER

Cons. Engr.
Casper, Wyo.; Mar. 23, 1953

The committee will be formed as soon as we have enough members to staff it.—SEDBL SECY.

One Man's Junk

To the Editor:

Reference is made to your comments in the "Correspondence" section of the March 1953 issue of the JOURNAL concerning the "junk" which is numbered separately for convenience in binding. Although the idea of separate numbering is good, I must disagree with the classification of the section titled "Condensation" as junk.

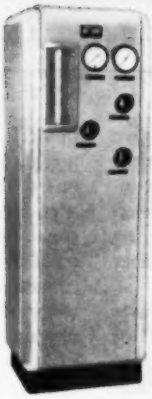
Recently I had my complete file of JOURNALS bound and gave the binder instructions to leave out the "unimportant" material and advertisements at the front and back of each issue. As is customary with university libraries, the "Abstracts of Water Works Literature" were considered as important and were included in the bound volumes. But just yesterday, I had occasion to refer to this section, now called "Condensation," and found that since 1948 these abstracts were

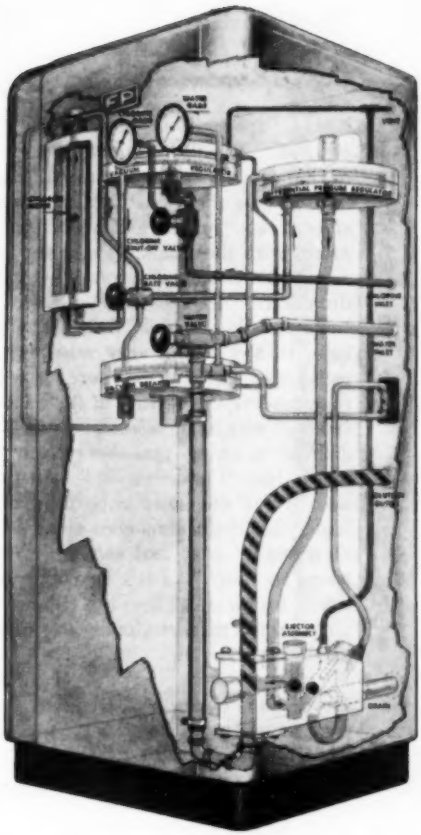
(*Continued on page 54 P&R*)

new

RATOCHLOR 1050

CHLORINE DISPENSER





every inch corrosion resistant

From cabinet to valves, every part of the new Ratochlor unit is as corrosion resistant as modern science and technology can make it, the result of years of field and laboratory tests in the handling of both dry and moist chlorine gas.

The complete outer cabinet is made of a new polymer-impregnated fibre glass material, whose attractive grey color permeates the entire material.

Control operations inside the cabinet center around a corrosion resistant Flowrator meter, which provides direct, accurate, wide range of chlorine flow rate. New corrosion resistant materials recently developed in the research laboratories make it possible to incorporate the safety and simplicity of the diaphragm-regulator principle in the 1050 Ratochlor. Water seals are eliminated.

The design of the new 1050 Ratochlor provides the fullest control of chlorine solutions, the most advanced materials and methods to combat corrosion. It can be readily adapted for program control, proportioning and remote control. A complete and comprehensive discussion of the new 1050 Ratochlor and its operation is available in booklet form. Write for Catalog 61 now.

CHECK THESE ADVANTAGES

- **SAFETY**
- complete corrosion resistance — using Uscolite, Teflon Kel-F, Tantalum and other materials
- direct, visible flow measurement
- maximum water economy
- dependability — minimum working parts
- solution feed standard (gas feed available)
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Correspondence

(Continued from page 52 P&R)

omitted. My first thought was to give the binder a piece of my mind, but, after finding that these abstracts are now considered as "junk," and numbered separately with the "junk," I can see that my comments should be aimed in another direction.

Personally I think that the abstracts have always been a very valuable part of the JOURNAL. Furthermore, I feel that they deserve the dignity of the name "Abstracts" which, in scientific circles, has a definite meaning far above such catchy words like "Condensation." And finally, and by far the most important, I would like to see them numbered along with the "important" part and separate from the so-called "junk" Let's keep the publication a JOURNAL. There are enough magazines on the market already to satisfy that need.

H. M. GIFFT

Head, San. Dept.
College of Eng.
Cornell Univ.
Ithaca, N. Y.; Mar. 17, 1953

The "junk," we hasten to point out, wasn't ours, though "Condensation" is. Meanwhile, we invoke economics again to explain why the abstracts are where they are, and call attention to the fact that their being there really helps make the Journal more of a journal.—ED.

More For

Continuing the comment on the Runoff portion of P&R (see January and March issues), seven more members have risen to the defense of levity. Excerpts from three of the letters are quoted below; the others asked to remain Readers Anonymous:

To the Editor:

It is understandable and inevitable, among the many snowballs tossed about in P&R, in a playful mood, that some few might be mistaken for barbs or poisonous darts. As for me, I have not as yet seen any item to which I might take personal umbrage, but my monthly vigilance continues. . . . My vote goes for the continuation of P&R, and I hope that your sources for bubbling miscellany do not dry up.

Yours for Safety in everything,
R. A. EDWARDS

Safety Director
American Water Works Service, Inc.
Philadelphia, Pa.; Feb. 18, 1953

To the Editor:

. . . I frequently read the JOURNAL in bed at night and have *never* fallen asleep while reading P&R, which is more than I can say for the front part of the book. Mind, the front part is good, and very necessary, even vital, but it needs P&R to strike a balance, lighten the weighty material of the articles and inject a little humor, or humanity, or anything you want to call it. I know fellows who read P&R first, then turn to the heavier problem articles and reports.

R. L. TYLER

American Water Works Service Co., Inc.
Philadelphia, Pa.; Feb. 19, 1953

To the Editor:

. . . I, for one, am an avid reader of P&R and I think the JOURNAL would lose a lot of its appeal if these columns were deleted. Obviously the technical papers, condensation, etc., form the meat of the JOURNAL, but who wants a whole meal of meat? A little tang from the wine of P&R improves the palatability of the fare no end.

N. J. GOODE

Public Health Engr.
Provincial Dept. of Health & Welfare
Victoria, B. C.; Mar. 19, 1953

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OF THE
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September 15, 1952

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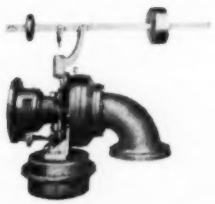

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The Reading Meter

Water Supply and Purification. *W. A. Hardenbergh. International Textbook Co., Scranton, Pa. (3rd ed., 1952) 516 pp.; $6.50*

This third edition of an excellent primer by the editor of *Public Works* maintains its standing as one of the primary reference books in the field, offering a useful grounding in the essentials of the collection, treatment, and distribution of water. Explanations are concise and clear, illustrations helpful and the entire approach is workaday and practical. It is unfortunate that, although considerable new material has been added, a few features could have been brought a little more up-to-date. For example, the exclusive use of the term "zeolite" to designate all ion exchange resins, and the omission—probably because it was too new when the book was being prepared for the printer—of the molecular filter membrane method for bacterial examination. It is quite probable, however, that those for whom this book is intended will consider that these points of refinement do not affect the basic principles they are seeking. For such a function, this book deserves recommendation.

Rosenau: Preventive Medicine and Hygiene. *Kenneth F. Maxcy. Appleton-Century-Crofts, New York (7th ed., 1951) 1,462 pp.; $15*

Better known to public health workers than to purveyors of water, Kenneth Maxcy's revision of Milton Rosenau's standard work supplies the "why" underlying the painstaking cares taken in the purification of water. Nowadays attention tends to be centered on refinements—removal of tastes and odors, anticorrosion treatment, softening—but it is good to review the dangers that even now lurk at the intake, and to remember what disinfection saves us from. In this context it is of interest to note the controversy aired in the correspondence columns of the April issue of *Scientific American*, in which a member of the Public Health Service challenged the credit given to quarantine for freeing the United States of cholera, and to inoculation, for eliminating typhoid, instead of (of course) water treatment.

The classic story of the conquest of typhoid fever is authoritatively retold, and junior water engineers who should know the grand tradition in which they are laboring can well be referred to it. In addition, there is a catalog of lesser-known ailments against which the treatment plant must stand guard: shigellosis (bacillary dysentery), amebiasis (amebic dysentery), leptospirosis, infectious hepatitis, and perhaps a multitude of parasitic worms. Nor are all these academic dangers: "All sewage-polluted water must be regarded as dangerous," the author tells us. "It is highly probable that the sewage of large communities contains typhoid bacilli and other disease organisms in larger or smaller numbers. . . ." As if this threat of contagion were not bad enough, attention is called to other disorders that can be produced by water: lead poisoning, infant methemoglobinemia, and what may perhaps be best described as plain and fancy diarrhea.

The author associates himself with the proponents of fluoridation, pointing out

(*Continued on page 58 P&R*)

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The Reading Meter

(Continued from page 56 P&R)

that "inadequate amounts of fluoride are associated with high rates of dental caries." It is interesting to note, in view of the suggestion made by Bratton (April JOURNAL, p. 367) that sodium silicofluoride may be more toxic than sodium fluoride, that Maxcy says the advantage of using the former compound is "some reduction in cost and a considerable reduction in toxicity; it may replace the sodium fluoride when studies on its effectiveness are complete."

A generous allotment of space is given over to a section on the sanitary control of water supplies, prepared by Edward W. Moore. The discussion goes beyond its nominal limits to give the reader a broader background on the workings and problems of water supply management, and discusses in detail the analysis of water and its interpretation.

Sewerage and Sewage Treatment. *Harold E. Babbitt. John Wiley & Sons, New York (7th ed., 1953) 674 pp.; $8*

Six editions from 1922 to 1947 have made Babbitt's *Sewerage and Sewage Treatment* even more of a byword in waste disposal than his *Water Supply Engineering* has become for water works. This seventh edition continues the tradition, and reinforces it. The publishers list an impressive array of additions and revisions made to take into account the continuing change in technology, as well as the more prominent place waste treatment is coming to occupy in industry and newer conceptions of public health and convenience.

The Law of Municipal Contracts With Annotated Model Forms. *Charles S. Rhyne. National Inst. of Municipal Law Officers, 730 Jackson Pl., N.W., Washington 6, D.C.*

A foreword by Albert H. Hall, executive director of the National Inst. of Governmental Purchasing, warmly recommends this volume as a "key advance" toward improving and standardizing public purchasing procedures, and adds: "This volume emphasizes the need for centralized purchasing in each city by adequately trained professional purchasing agents. It illustrates the pitfalls which arise for those who do public buying without requisite knowledge and experience. Ignorance of the law in public purchasing is costly. . . ."

Model contract forms, carefully annotated, provide concrete help for the municipality wishing to apply the principles outlined by the book.

The Industrial Utility of Public Water Supplies in the East North-Central States, 1952. *E. W. Lohr, P. N. Brown, and W. L. Lamar. Circular 253, Geological Survey, Washington 25, D.C. (1953) 125 pp.; paperbound; free*

This is the sixth report of a projected series of nine that will cover the United States, and deals with the states of Illinois, Indiana, Michigan, Ohio, and Wisconsin. Basic information about water supply and treatment, and analyses of the waters, are given for each of the public supplies in the area. (For previous reports issued, see JOURNALS for October 1952, p. 92 P&R; December 1952, p. 20 P&R; and January 1953, p. 50 P&R.)

American Standard Brass or Bronze Flanges and Flanged Fittings, 150 and 300 lb—ASA B16.24–1953. *American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N.Y. (1953) 9 pp.; paperbound; $1*

The standard is a joint production of the Heating, Piping, and Air Conditioning Contractors National Assn., the Manufacturers Standardization Society of the Valve and Fittings Industry, and the American Society of Mechanical Engineers. It was given American Standards Assn. approval on February 27, 1953.

(Continued on page 60 P&R)

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The Reading Meter

(Continued from page 58 P&R)

Specification Index of Construction Items and Materials. *Allen V. Rothermel, 120 N. 21st St., Camp Hill, Pa. (2nd ed., 1953) 102 pp.; paperbound; $5*

Greater pains appear to have been taken, in this second edition of a finding list for construction standards, to have the entries as current as possible. Some little defects are still apparent, and tend to impair the ease with which an otherwise helpful reference can be used. For example, despite commendable efforts at cross-indexing, all the specifications for cast-iron water pipe will not be found under the heading, "Pipe, cast-iron" (although such standards as ASA A21.1 will be found there twice, once under the ASA designation and once with the AWWA number). But two full pages away, separated from its fellows by such items as Pipe Insulation and Pipe Threads, may be found federal specification WW-P-421, alphabetized as "Pipe, *Water,* Cast-Iron. . . ." A little imagination and effort, however, should always be brought to reference works, and if this index does not have all the answers, it will at least provide a good starting point for tracking them down.

The Recovery of Ground-Water Levels in Brooklyn, New York, From 1947 to 1950. *Norbert J. Lusczynski. Circular 167, Geological Survey, Washington 25, D.C. (1952) 29 pp.; charts; paperbound; free*

An account of the steady recovery of ground-water levels in Brooklyn after the city discontinued the franchise of a local utility using wells and supplied its regular "upland" water to the Flatbush area. Although the water table in most areas has risen from below to above sea level, it is expected that it will be years before the salt-water intrusion is completely eliminated.

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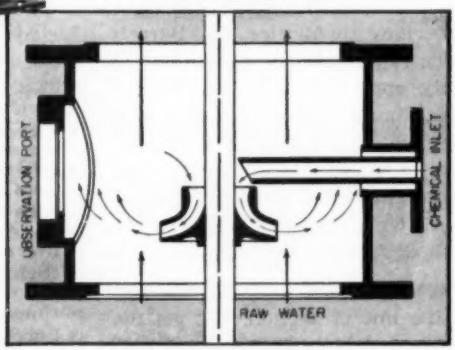

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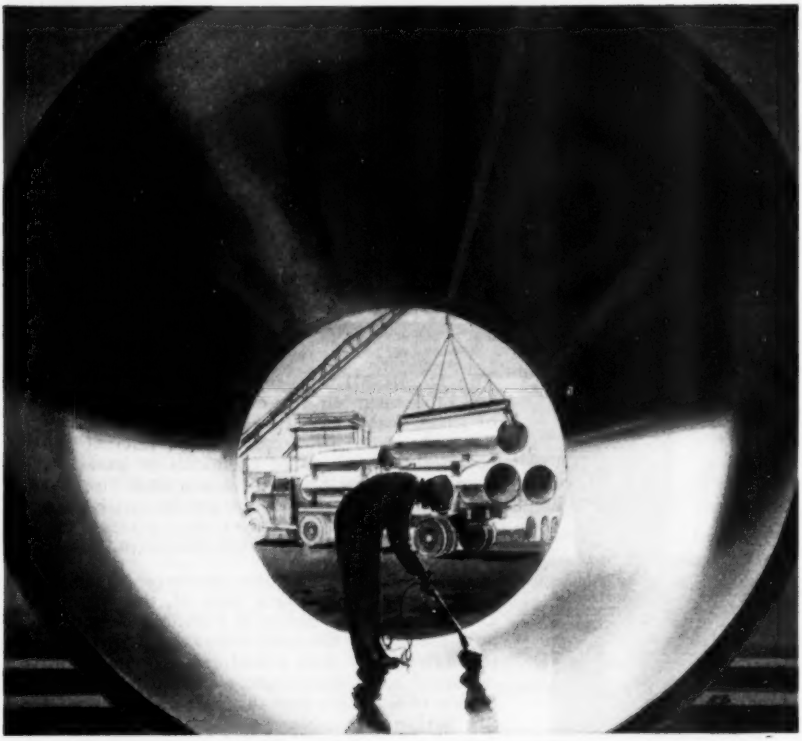

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

DISTRIBUTION SYSTEMS

The Covering of Two Service Reservoirs With Barrel-Vault Roofs. C. A. SERPELL. J. Inst. Wtr. Engrs. (Br.), **6**:343 ('52). In Sept. '48 Sunderland and South Shields Water Co. received complaints from Sunderland area of wormlike organisms in water. It was evident that enclosing of water surfaces would considerably reduce biological activity. Low reservoir has capac. of 0.8 mil gal (Imp.) with dimensions at top water level of $130' \times 98'$, and high reservoir has capac. of 1.2 mil gal and dimensions of $160' \times 100'$. Floors consist of puddle clay with min. thickness of 18", paved with either bricks or earthenware flags. Walls are masonry-faced brick of gravity section. Large-span, reinforced concrete barrel-vault roof appeared to offer means whereby whole of roof load could be transferred to more stable foundations provided by reservoir walls. Roofs were designed to carry superimposed load of 15 psf. Loading superimposed by roof on walls was roughly 1 ton/ft run of wall. It was considered undesirable to allow formwork to be permanently incorporated in finished structure, and all shuttering was completely stripped. Steel reinforcement was complex. All concrete complied with Code of Practice 114. Concrete aggregates were gaged volumetrically. Water demand of mix was estd. from accurate measurement of workability of concrete by apparatus developed for lab. use that detected 2% change in total water content of mix, providing means whereby water–cement ratio can be maintained within close limits. Cube tests show that avg strength of concrete for low reservoir is 1,000 psi greater than for high reservoir. This is attributed to variation in qual. of cement. In placing concrete, importance was attached to its curing, and barrels were covered with double layer of hessian which was kept continuously wet for 7 days. Min. striking time for forms was 7 days on barrel soffits and 21 days for valley beam supports. Barrels were constructed with initial cambers which varied according to deflection anticipated. Where practicable, cracks were filled with paraffin wax; finer cracks are sealing themselves with efflorescence of concrete. There is no indication of rusting of reinforcement, and existing cracks are causing no anxiety. At low reservoir, there was lateral movement of roof $\frac{1}{2}$" westward in first 6 mo. No movement has taken place since then, and, at high reservoir, there has been no appreciable lateral movement of roof. Concluded that reinforced concrete barrel-vault form of construction can readily be adapted for covering service reservoirs and is particularly applicable to smaller reservoirs where it is undesirable to apply additional load to existing floor or to excavate through it.—*H. E. Babbitt*

The Design of Reinforced Concrete Reservoirs and Tanks to Comply With the ICE Code of Practice. A. G. FLATT & J. W. PERKS. Wtr. & Wtr. Eng. (Br.), **56**: 259, 304, 356 ('52). Some important provisions of Inst. of Civ. Engrs. code which affect design are: [1] calculation of stress shall be based on: (a) plane sections remaining plane after bending, (b) steel and concrete being perfectly elastic, (c) no tensile strength in concrete when calculating strength of structure, (d) concrete being capable of sustaining tensile stress in resistance to cracking; [2] stress in steel not to exceed 12,000 psi with modular ratio of 12; [3] in resistance to cracking, stress in concrete not to exceed 250 psi on water-retaining face; [4] slabs not less than 4" thick nor less than 1" plus $\frac{1}{40}$ of depth of water above portion considered; and [5] in each of 2 directions at right angles, min. percentage of reinforcement is 0.3. Four basic design cases which can occur are: [1]

(Continued on page 70)

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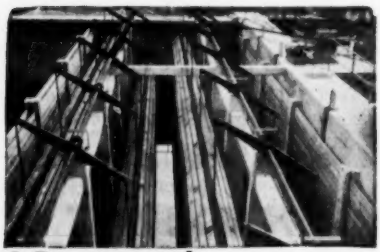
(Continued from page 68)

direct tension only, [2] bending only, [3] combined bending and tension, and [4] combined bending and compression. For bending only, with tension on water face, thickness of member is found from $D = \sqrt{\frac{BM}{Q'b}}$ where Q' is critical value, and reinforcement may be found either from $A_t = \frac{BM}{10{,}200d}$ or as ratio $p = \frac{Q'}{10{,}200k}$, where A_t is area of tensile steel; b is breadth of member; BM is bending moment; d is effective depth of member; $k = \frac{d}{D}$; $p = \frac{A_t}{bD}$; and Q' is qualifier of resistance moment MR with $MR = Q'bd^2$. With compression on water face and slab less than 9″ thick, foregoing method of design is used as if there were tension on water face. When slab is more than 9″ thick, resistance to cracking is not considered and normal design methods are followed with m, modular ratio, = 12; t_t, tensile stress in steel, = 12,000 psi; c_t, tensile stress in concrete, = 880 psi; $d = \sqrt{\frac{BM}{174b}}$; and $A_t = \frac{BM}{10{,}200d}$. In combined bending and tension, with $\frac{BM}{T} > d - \frac{2}{D}$, single reinforcement, and tension on water face, $c_t = \frac{T}{bd(1 + 11p)} + \frac{BM}{RbD^2} \geqq 250$ psi, where $R = \frac{0.333 + 11p(k - n_1)^2}{(1 - n_1)} - n_1$ and T is direct tension. With single reinforcement and compression on water face where slab is less than 9″ thick, above method of design is used as if there were tension on water face. Where slab is more than 9″ thick, normal methods of design are used with $d = \sqrt{\frac{BM}{174b}}$ and $A_t = \frac{M - T(d - \frac{1}{2}D)}{10{,}200d} + \frac{T}{12{,}000}$. Pressures acting on walls of reservoirs and tanks are normally those due to water inside tank

(Continued on page 72)



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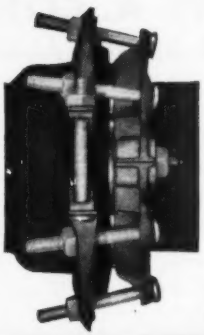

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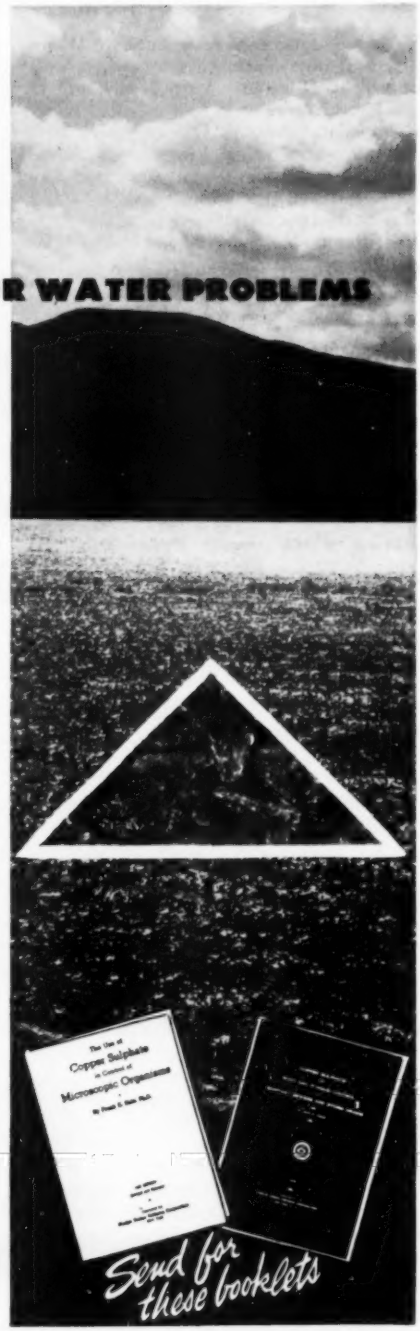

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and to soil outside tank if buried. Water pressure at any depth, h, is wh, where w is unit weight of water. Vertical pressure of earth is wh, where w is unit weight of soil; and horizontal pressure is Kwh where K is coefficient whose value depends on internal soil friction and conditions of surcharge. In waterlogged soil, precautions must be taken that tank does not float when empty. In open rectangular tanks, with walls spanning horizontally, single compartment tank, and square in plan, corner moments $M_x = \frac{PL^2}{12}$ and mid-span moments $M_L = \frac{pL^2}{24}$, where p is pressure at depth considered and L is effective span of sides. In single-compartment tank, rectangular in plan, with dimensions B and L, thickness of wall whose length is $L = D_L$, and thickness of wall whose length is $B = D_B$, corner moments $M_x = \frac{p}{12}\left(\frac{B^3D_L^3 + L^3D_B^3}{BD_L^3 + LD_B^3}\right)$. Following direct tensile forces must be combined with bending moments: $T = \frac{pL}{2}$ in wall B and $T = \frac{pB}{2}$ in wall L. In double-compartment tank, both sides empty or both sides full, $M_x = \frac{p}{12}\left(\frac{L^3 + 2B^3}{L + 2B}\right)$ and moment at center of L wall $M_y = \frac{p}{12}\left(\frac{L^3 + 3L^2B + B^2}{L + 2B}\right)$; direct tensile force to be combined with bending moments will be $T = \frac{pB}{2}$ in wall L and $T = \frac{pL}{2} + \frac{M_x - M_y}{L}$ in wall B. In double-compartment tank, one side empty and other side full, structure may be analyzed most simply by method of moment distribution.—*H. E. Babbitt*

Some Aspects of Valve Engineering in Water Supply. P. L. Boucher. J. Inst. Wtr. Engrs. (Br.), **6**:397 ('52). Use of valves in pipelines is said to go back at least 2,000 yr. Ancient examples appear to be plug cocks. Invention of sluice or gate valve has been claimed for Nasmyth in 1839, but sliding gate appears to have been installed in New York City in 1776. Slide valves were used in Rivington Aqueduct for Liverpool in 1857. In 1952 sluice valves have become subjects for mass-production. Max. working pressure of sluice valve, equal usually to half test pressure, has no relation to unbalanced pressure against which valve can readily be operated by hand. Object of bypass is to relieve unbalanced pressure on valve gate to reduce operating forces. It is widely understood that handwheel is turned clockwise to close valve while T-key is turned counterclockwise for closing. As no general agreement exists, exceptions can have deplorable consequences. Valves for water works pipelines and pumping installations are usually of cast iron with gunmetal faces on body and gate. Power operation of large sluice valves has number of advantages: they can operate at higher speeds and can be controlled automatically from remote situations under different circumstances. Electrically controlled valves are well suited to remote control. Hydraulic valves are usually designed for operation with cylinder pressure of same order as pressure in main. They have important large-scale applications in automatic control, as self-closing valves to guard against flooding from bursts in trunk mains and as delivery valves for large centrifugal pumps. Recent progress in hydraulic operation has been made in application of highly developed hydraulic automotive mechanisms, especially in smaller sizes of valves. Use of centralized hydraulic control of filter valves has saved labor and speeded up filter bed cleaning. It has proved feasible to adapt fully automatic control to filters of conventional type. Sequence of valve operation in control of base-exchange water-softening units is particularly well adapted to automatic control. Except for small pipes and low pressures, possibility of erosion and cavitation makes sluice valves unsuitable where flows through pipes are adjusted by means of regulating valves which have to stay for long perods of time in partly closed positions. Single- or double-beat disc type valve, ported if necessary, sensibly in hydraulic equilibrium, is employed, with passages so arranged that cavitation and erosion are avoided. When flow regulation takes place at end of pipeline or where free discharge into air is obtained, needle or spear type control valve is suitable. Flow-regulating device known as module appears to have been devised for irrigation duty to apportion water from open canals. Italian and Spanish modules represent two types. Candy module is of fully enclosed type for use with pressure filters. Microme-

(Continued on page 74)

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(Continued from page 72)

ter module is remarkable for minute rate of flow at which it functions. Float valve is automatic flow control valve in which controlling factor is level of free water surface.—*H. E. Babbitt*

Water Distribution System Materials and Practices. E. J. ALLEN. Munic. Util. (Can.), **90**:6:62 (June '52). Seattle, Wash., system consists almost entirely of c-i pipe, lined with Portland cement mortar ($\frac{3}{32}$" lining in 4"–12" pipe, $\frac{1}{8}$" in 16"–24", and $\frac{5}{32}$" in 30"–48") and brushed or sprayed with bituminous seal coat while cement still wet. Outside coated with coal-tar pitch varnish. Some larger transmission mains cleaned and so lined *in situ*. HTH placed in each length during constr., and whole line thoroughly flushed through each hydrant after pressure testing. Chlorine then introduced until more than 60-ppm residual found at each hydrant or leg, each gate being operated while main under pressure, and line left under pressure overnight. Flushed following day until residual normal, again allowed to stand overnight, and then water examd. bacteriologically. Samples should not be collected from hydrant port. Square-braided, untreated yarn has caused no trouble in disinfection. Grounding only of noncurrent-carrying parts of elec. system to water pipes permitted. Shortly, grounding of neutral wire, as prescribed in National Electric Code, '51, will be approved, but right to use nonmetallic pipe and joints will be specified in ordinance.—*R. E. Thompson*

A Technique for Salvaging Pipe Under Street Crossings. B. P. LEDBETTER & HUGH WILBANKS JR. Corrosion, **8**:185 ('52). Description given of method of removing 750' of 6" and 8" wrapped steel gas main from beneath street crossings without cutting street. Burner placed in one end of pipe under streets heated main to flow point of coal-tar enamel coating; then, with winch line, pipe was pulled out of its felt wrapper, using melted coal-tar enamel as lubricant. Procedure permitted recovery of pipe which could not have been saved economically otherwise. Details of technique given, and operations illustrated with photographs. Inspection of coating on removed pipe indicates application of coal-tar enamel in excess of $\frac{3}{32}$" in type of soil encountered would be of very little value.—*Corr.*

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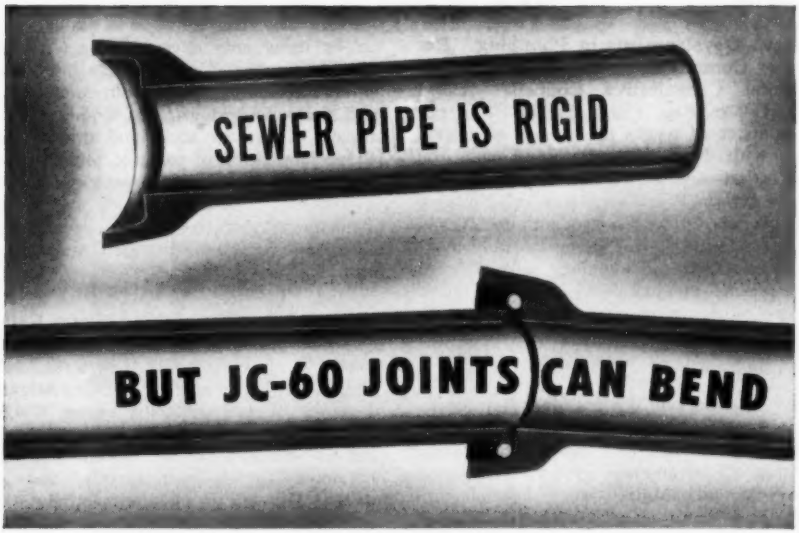

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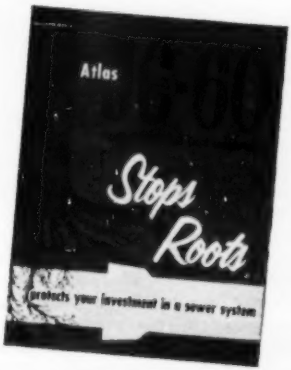

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(*Continued from page 74*)

Modern Developments in Plumbing. Report of Committee of Ministry of Works National Consultative Council. ANON. Wtr. & Wtr. Eng. (Br.), **55**:174 ('51). In '50 minister of works held series of discussions with Natl. Consultative Council on observations and recommendations contained in reports of Working Party on Building and Anglo-American Productivity Team. Ad hoc committee was set up to study modern developments in plumbing with particular reference to practice in U.S. Important feature of American practice is completion of fully detailed schemes of plumbing and drainage as part of main design of building before bids are received. Relative simplicity of American layouts for water supply is partly due to general absence of cold-water storage cisterns. American practice features use of one-pipe system of soil and waste disposal. Matter which deserves further development is prefabrication of parts of plumbing systems in workshops set up on site itself and provision of specialized hand- or power-operated equipment for this work. Information available in Postwar Building Studies No. 4, "Plumbing," and No. 26, "Domestic Drainage," and in certain British standard codes of practice has done much to clarify points of efficient practice. Committee concludes that: [1] detailed schemes for plumbing and drainage should be prepared as part of main design before bids are invited; [2] local authorities should regularly review their requirements to insure that sound development in plumbing is not unnecessarily prevented from being brought into use; [3] examination and approval of plumbing and drainage schemes and inspection of work should be undertaken only by officers with specialized knowledge, and provision should be made for inspection while installation is in progress; [4] for water supply, advantages are offered by system in which cold-water storage cisterns are provided only to supply hot-water tanks, while all other outlets are connected to mains; [5] in designing plumbing layouts for water supply in buildings, more attention should be paid to close grouping of appliances, simple joints, adequate space for pipework and components, and easy access for maintenance; [6] one-pipe system of soil and waste disposal should be more widely adopted; [7] there is considerable scope for effecting economies in underground drainage by using only most suitable pipe sizes, reducing number of manholes to min., eliminating intercepting traps from connection to new sewerage systems, and avoiding excessive use of concrete under and around pipes; [8] prefabrication of parts of plumbing systems in well-equipped field workshops should be adopted; and [9] there is urgent need of publicity for up-to-date developments with detailed examples of their practical application.—*H. E. Babbitt*

Contamination of Drinking Water Caused by Machine Operations Cross-Connections. G. M. HAMA & H. JAWORSKI. Mod. Sanitation, **4**:43 (Sept. '52). Investigation of report of gastroenteritis among machinists revealed existence of cross-connection between drinking water system and tank containing soluble cutting oils, and also sewer. Although cannot be definitely stated that contamn. of water supply caused illness, facts indicate contamn. of drinking water took place. Cross-connections were eliminated by installation of 2 backflow preventers, 4-way valve, check valve on water piping, and air break at connection to sewer. —*PHEA*

FLUORIDATION

Aspects of Fluoridation. R. L. DERBY. Sanitarian, **15**:13 (July–Aug. '52). Brief historical review of subject of fluoridation indicates growing interest in possibility of reduction of dental caries through optimum fluoridation of water supplies. It is pointed out, however, that consensus of authorities is not universal in recommending fluoridation without adequate surveys and controls; many expressed opinion that more research should be done to det. possible ill effects from fluoridation of water supplies. Arguments both for and against fluoridation are given, as well as suggested methods for ingesting fluorine by methods other than in water. Methods of treatment of water supplies are discussed briefly, with comparison of advantages and disadvantages of principal fluoride compounds, as well as author's opinion of steps which should be taken by community contemplating fluoridating its water supply.—*PHEA*

The Case for Water Fluoridation. J. W. KNUTSON. New Eng. J. of Med., **246**:737

(*Continued on page 78*)

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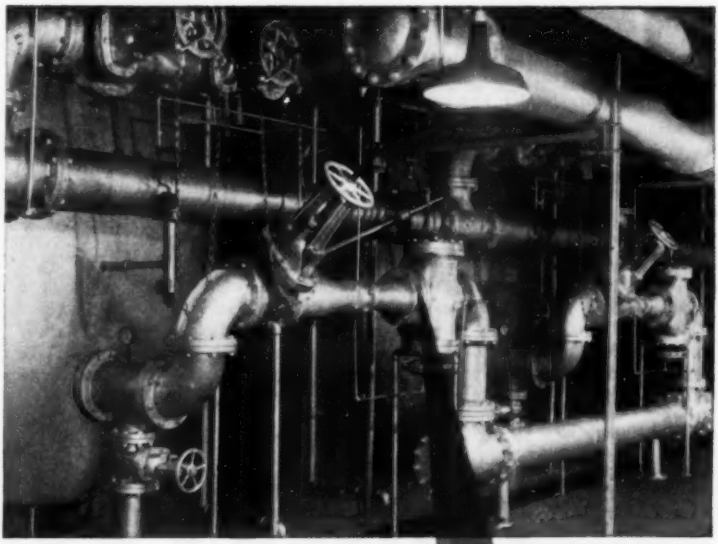

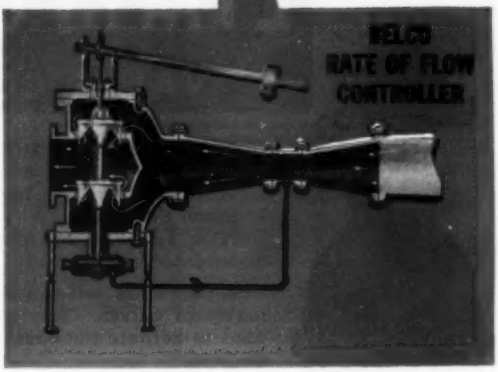

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OUR REPRESENTATIVES IN U.S. AND CANADA — THOMAS R

(Continued from page 76)

('52). Of more than 16,000 public water supplies in U.S., less than 1% have had fluoride added to water. Author ests. that at present rate of progress it will take at least 150 yr to secure fluoridation of all supplies, and he feels that present slow advance is not due mainly to indifference or conservatism, but to lack of information and to misinformation on subject. Accordingly, he devotes part of his article to acct. of what has already been accomplished by controlled fluoridation at Grand Rapids, Mich., and he gives table showing percentage caries reduction similarly achieved in 6 other communities. He then deals with various objections put forward by opponents of fluoridation. Some of these are rather vague as, for example, that process is form of "mass medication" or that it is "tampering with nature." Others are more definite, such as toxicity of fluorine, its alleged tendency to produce fragility of bones, and its undoubted power to produce enamel mottling when concn. in drinking water is high. Author points out that more than 3,000,000 Americans have lived all their lives in naturally fluoridated areas without their general health having thereby been adversely affected in slightest degree. Available evidence all goes to show that harmful results are to be found only with very high concentrations of fluorine; as National Research Council put it: "The margin between the optimal quantity of fluoride in drinking water which is required for maximal benefit in tooth development, and the amount which produces undesirable physiological effects is sufficiently wide to cause no concern."—*BH*

Fluoridation of Public Water Supplies in West Virginia. H. K. Gidley. Health Views, 3:1 (Apr. '52). In West Virginia, cities of Wheeling, Weirton, and Ripley are fluoridating, and several others will be within coming year. About 200 of 16,000 public supplies in U.S. are being fluoridated. Significant amounts of natural fluoride in public supplies in West Virginia are rare. State-

(Continued on page 80)

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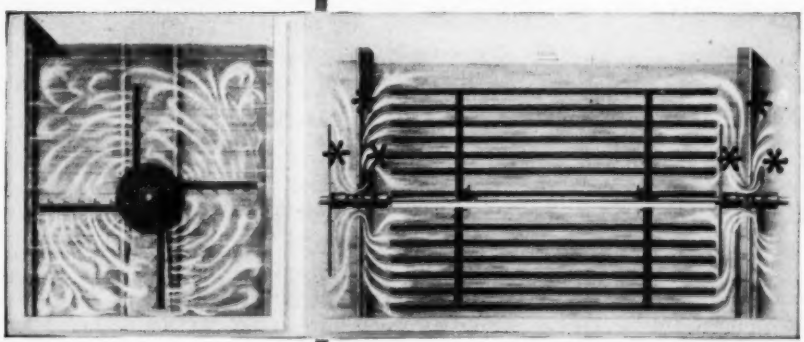

Cross-sectional view from head of tank showing mixing action.

Cross-sectional side view of Floctrol showing flow.

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(Continued from page 78)

wide survey of public water sources will be taken in '52. Studies indicate 1 ppm fluoride ion is needed for best tooth protection. Dental survey made in Weirton in '51 indicated that decayed, missing, and filled teeth of Weirton children was about 2.3 times greater, and missing permanent teeth about 4 times greater, than in Aurora, Ill., whose water supply by nature contains optimum amt. of fluoride. In application, fluoride compound such as sodium fluoride, sodium silicofluoride, ammonium fluosilicate, or hydrofluosilicic acid is accurately proportioned to water before it is pumped into distr. system. Sodium fluoride, most used in small plants, is dissolved and solution is pumped into water; at 15¢/lb, requiring 20 lb/mil gal, cost is $3.00/mil gal. Sodium silicofluoride, widely used in large plants, is measured and applied mechanically as powder; at 9¢/lb, requiring 14 lb/mil gal, cost is $1.26/mil gal. Equipment for small plant will cost $500–$800; for large plant, $800–$3,000. Permits for fluoridation are issued to water utilities by state health dept. when installations comply with standards covering permissible dosage, accuracy of feeding equipment, methods of handling fluoride, daily control tests, and records. Fluorides are toxic and must be handled with care. Continued overdose of fluoride will cause discoloration or mottling of teeth, but occasional overdose slightly exceeding 1.5-ppm desirable upper limit can be tolerated.—*PHEA*

Fluoridation of Municipal Waters. F. S. McKay, A. P. Black, M. E. Nickolson & F. A. Bull. Pub. Health Rpts., **67**:36 ('52). Symposium presented before 92nd annual session of American Dental Assn. in Oct. '51. Fluoridation not recent discovery, as indicated by British dentist's statement, prior to 1892, on fluorine in human diet and its effect on sound teeth. Authors trace recent discovery of fluorine in drinking water and its therapeutic value in prevention of dental caries. Each of these authors, although in different fields of dental health, tells same story of effectiveness of proper amt. of fluorine in controlling most common disease of today. Bull states that it is not cureall, but McKay says that fluoridation, during period of tooth calcification, is only known agent ordinarily included in diet that is capable of exercising mass control of dental caries. —*PHEA*

Laboratory Investigations on the Relation of Fluorine to Dental Caries on Tyneside and District. G. N. Jenkins, P. A. Armstrong & R. L. Speirs. Proc. Roy. Soc. Med. (Br.), **45**:517 (Aug. '52). 2 main theories have been suggested to explain caries-inhibitory action of fluorine. One is that fluorine, when incorporated in tooth structure, reduces its acid solubility; other is that its protective action against caries depends on antibact. mechanisms. Authors discuss principal investigations which have provided arguments in support of each of these theories and, finding them somewhat unconvincing, record their own investigations with teeth obtained from residents in North Shields, South Shields, and West Hartlepool. Fluorine content of drinking water in those 3 towns had been recorded as follows: North Shields, less than 0.25 ppm ('43); South Shields, 1.4 ppm ('43); and West Hartlepool, 2.0 ppm ('49). There are reasons for believing that since '43 there has been reduction of nearly 50% in fluorine content of South Shields supply. Intact deciduous teeth from North and South Shields were compared for solubility by Brudevold's method, and, though South Shields teeth were slightly less soluble, difference was not signif. Comparison, however, between deciduous teeth from North Shields and from West Hartlepool showed highly significant difference in solubility, amtg. to 42% less in West Hartlepool. When same expt. was repeated with adults' teeth from these 2 towns there was no significant difference—somewhat surprising result for which authors have no explanation. Their figures show clearly that reduced solubility of intact West Hartlepool deciduous teeth is confined to surface of enamel. 2 possible interpretations suggest themselves: either solubility is reduced because of chem. difference between surface and interior of tooth (and higher fluoride content due to direct acquisition of F from drinking water might acct. for this), or there is some architectural difference between surfaces of fluorosed and nonfluorosed teeth. When enamel of deciduous teeth was powdered and its solubility in ground state estd., it was found that there was no significant difference between North Shields ground enamel and that derived from West Hartlepool teeth. Using modification of Wach test, authors estd. acid production of saliva obtained from children

(Continued on page 82)

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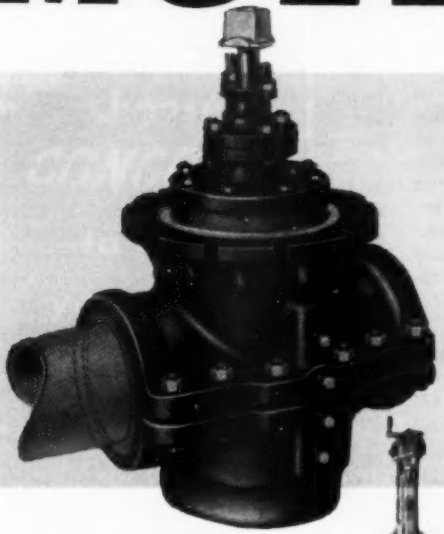

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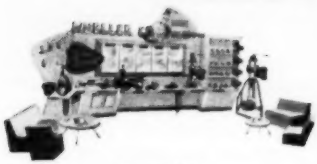

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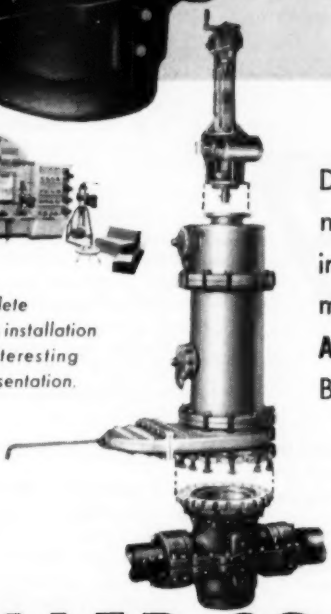

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(*Continued from page 80*)

living in North Shields and West Hartlepool. Neither initial nor final saliva pH showed any signif. difference as between 2 towns. So far as *Lactobacillus* counts were concerned, it was tentatively concluded that West Hartlepool saliva samples contained somewhat higher proportion of low counts and lower proportion of high counts than samples from North Shields. Results of subsequent expts. did not confirm claims which have been made that low levels of fluorine—1 ppm or thereabouts—are extremely inhibitory, and authors conclude that concns. of 10 ppm seem to be necessary before any consistent decrease in acid production occurs. Even at that level, decrease may not be large enough to have any signif. effect on caries incidence.—*BH*

Study of Ninety-Eight Communities Fluoridating Their Communal Water Supply. L. F. MENCZER. Am. J. Pub. Health, **42**: 1414 ('52). Need for new dental decay preventive techniques has long been sought, and fluoridation of communal water supplies solves part of this problem. Survey was undertaken of all communities fluoridating their communal water supply as of Oct. 15, '51. 98 communities reporting fall into following population categories: 22, less than 5,000; 22, between 5,000 and 10 000; 35, between 10,000 and 50,000; 12, between 50,000 and 100,000; 7, over 100,000. 54% of those reporting are using sodium fluoride; 43%, sodium silicofluoride; 3%, hydrofluosilicic acid or hydrofluoric acid. None reported difficulty in obtaining chemicals. Fluoride dosage of water varied from 0.5 ppm for summer months in southern states to 1.4 ppm for winter months in northern states, depending on water consumption, which in turn is dependent upon mean minimum and mean maximum temperatures. 90% of reporting cities financed fluoridation from water revenue. Remaining 10% financed fluoridation from general funds (6%) and health department and other funds (4%). 98% of all reporting communities had fluoridation brought about through action by dental, medical, and public health groups as well as an informed public. In only 2% was fluoridation submitted for public referendum. With reference to complaints received concerning fluoridation, 80% reported no complaints at all. Remaining 20% reported isolated complaints, but these were purely imaginative as, in almost every instance, complaint was registered between date of announcement of fluoridation and actual date of inception of program. Fluoridation is feasible, has tremendous public support, is inexpensive, and within optimum limits is safe and beneficial.—*PHEA*

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HEALTH AND HYGIENE

An Outbreak of Waterborne Gastroenteritis and Sonne Dysentery. A. I. ROSS & E. H. GILLESPIE. Min. of Health & Pub. Health Lab. Service Monthly Bul., **11**:36 (Feb. '52). Excellent and full account of outbreak of gastroenteritis and dysentery caused by pold. water—source of infection which has become rare in Britain in recent years. First information of outbreak came on morning of Dec. 20, '50, from notification of occurrence of 18 cases of diarrhea

(*Continued on page 84*)

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(Continued from page 82)

and vomiting among 1,250 employees in large factory. It was stated that some employees had noticed that water from taps in canteen had bad odor. On inspection of canteen, it was found to be scrupulously clean and well run. Samples of water from canteen on bact. examn. gave presumptive coliform count of 180+ per 100 ml, and chem. examn. also revealed gross contamn. More cases of gastroenteritis occurred, and ultimately total of 160 employees and 28 persons in neighboring houses were known to have suffered. Histories were obtained from 145 of affected persons, but unfortunately stool specimens could be obtained from only 66 of sufferers, perhaps owing to proximity of Christmas and also to mildness of disease. *Sh. sonnei* was isolated from 9 specimens. *Sh. flexneri* and *S. typhimurium* were also found, in one specimen each. Cause of outbreak was ultimately detd. It was found that factory had 2 supplies of water, one from Leicester's purified supply and one from river used unpurified in mfg. processes. Owing to dirtiness of river water it had been found unsuitable for use, and on Dec. 17 connecting pipe had been placed between river water supply pipe and town supply pipe, in order to make use of purified water for factory purposes. Unfortunately valve fitted to prevent any communication between 2 supplies had by oversight been left open. River water was at 240 psi pressure, town supply at 25–30 psi, and hence was driven into outside mains, so accounting also for cases in neighboring houses. Sonne dysentery had been epidemic in Leicester since beginning of Aug. '50. *Sh. sonnei* was later isolated from river water.—*BH*

Epidemic of Viral Hepatitis Apparently Spread by Drinking Water and by Contact. J. D. Farquhar, Joseph Stokes Jr. & W. D. Schrack Jr. J. Am. Med. Assn., **149**:991 (July 12, '52). Epidemic of acute infectious (epidemic) hepatitis affecting 22 persons occurred in isolated rural area of Pennsylvania. Origin of infection could not be detd., but subsequent cases were traced to one farm. Well water on this farm was found to be fecally contamd., presumably from nearby cesspool. Infection was apparently spread both by drinking water and by contact.—*PHEA*

Cyanosis in Infancy From Nitrates in Drinking Water. M. C. Ewing & R. M. M. White. Lancet (Br.), **260**:931 ('51). Two cases of methemoglobinemia in infants are reported. Water drawn from shallow pold. wells in Suffolk was used in preparing both infants' food. Nitrates were present at concn. of 200 ppm and 95 ppm.—*WPA*

Pollution of Potable Water and Watered Milk by Nitrates as a Cause of Methemoglobinemia in Infants. C. G. Macris. Iatr. Proodos, **52**:2 ('51). Water contg. more than 10 ppm nitrate is dangerous for infants. When the water is used for dilg. milk, concn. of nitrate below 10 ppm might be reduced by bacteria in the milk to give toxic concn. of nitrite. Concn. of nitrate in samples of water and watered milk during storage is shown in tables.—*WPA*

Water and Virus Diseases. G. B. Roemer. Deut. Med. Wochschr. (Ger.), p. 941 ('49). Existing literature on the transmission of poliomyelitis and epidemic jaundice by water supplies and sewage is reviewed. Chlorination is not a certain method of destroying the viruses.—*WPA*

Study of Chromium Toxicity by Several Oxygen Demand Tests. R. S. Ingols & E. W. Kirkpatrick. Anal. Chem., **24**:1881 ('52). Toxicity of chromium in its various forms has been studied, using 3 techniques for determining BOD. Data indicate that toxic level of chromium is controlled by several variable factors, including presence or absence of oxygen, valence of chromium, type of organism (autotrophic or heterotrophic), and amount of organic matter present (rate of metabolism). Possible mechanism for chromate ion toxicity under anaerobic conditions is discussed, and it is suggested that mechanism for chromic ion toxicity is simply one of inert, small particle interference.—*PHEA*

The Irrigation of Truck Crops With Sewage-Contaminated Water. S. G. Dunlop. Sanitarian, **15**:107 (Nov.-Dec. '52). Report of field study on actual irrigation water and on growing crops which have been irrigated with dild. raw sewage or treated sewage. Many methods were used

(Continued on page 86)

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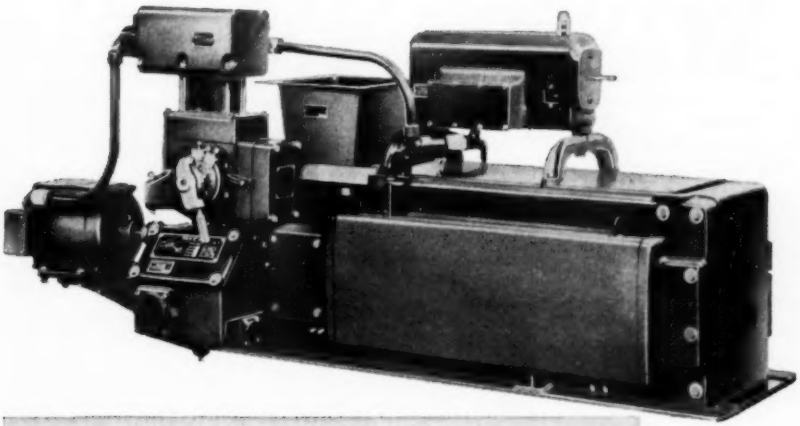

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(*Continued from page 84*)

to isolate pathogenic organisms from irrigation water. In one series of 113 samples of natural irrigation water, *Salmonella* was isolated from 23 samples. In these 23 positives were 13 different species of *Salmonella* and one isolation of *S. typhi*. Of 45 samples of celery, lettuce, and cabbage irrigated with this water, however, not one sample was positive for *Salmonella* organisms. With large samples of water, especially, there was definite correlation between coliform counts and incidence of *Salmonella*. Enterococci also showed some correlation. Significant proportion of irrigation water samples contamd. with treated and untreated sewage effluents can be shown to be contamd. with pathogenic microorganisms. These organisms are rarely isolated from washings of vegetables irrigated with this water. Potential public health hazard has been shown to exist, and adequate treatment of all domestic and industrial wastes before they are discharged into streams used for irrigation purposes is advocated.—*PHEA*

LABORATORY METHODS

An Incubation Room for Algal Cultures in Water Supply Taste and Odor Research. C. M. PALMER. Phycological Soc. Am. News Bul., **16**:9 (Feb. '52). Pure cultures are required in studies of algae causing tastes and odors in water supplies. Suitable incubation space is provided by insulating small room provided with air-conditioning thermostat, fluorescent lights, and glass shelves. Incubation temperature is 70°F. Illumination varies from 20 to 350 ft-candles. Room has volume of 550 cu ft and provides space for 1,000–3,000 cultures.—*PHEA*

A Reproducible Standard for the Calibration of Turbidimeters. H. E. ROSE. J. Inst. Wtr. Engrs. (Br.), **5**:310 ('51). Correctly designed turbidimeter is absolute apparatus; so, strictly, requires no calibration. However, owing to numerous deviations from ideal occurring in practice, it is generally essential to calibrate to obtain agreement of results between different workers. Basic

(*Continued on page 88*)

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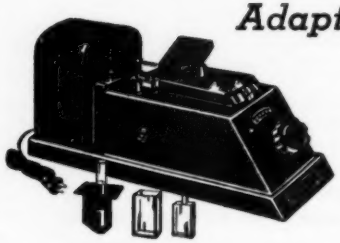

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(Continued from page 86)

equation of turbidity method of analysis is:

$$\log \frac{I_0}{I_1} = Cl\frac{\pi}{4}\sum_{0}^{d} Knd^2$$

where I_0 and I_1 are incident and emergent light intensities, respectively; l is length of light path through suspension; C is concn. of suspended material; n is number of particles of size d per gram suspended material; and K is ratio of light obscured by small particle to that which would be obscured if laws of geometric optics held. Need for calibration is due to considerations of convenience and is not introduced by necessity for exptl. detn. of empirical constants in basic equation. Use of natural mineral powders for prepn. of calibration suspensions is unsatisfactory, as opacity of suspension produced depends on size-frequency of powder. Strictly accurate calibration can be obtained only when calibrating material has same refractive index as material suspended in water. Proposed standard would probably not fulfill this condition. However, errors would be small. (Technique for prepn. of standard is given in detail.) By means of calibration curve, turbidity of water can be quoted in either of scales suggested; and as scales are based on common standard, values obtained by different workers upon widely different types of apparatus are strictly comparable. Exptl. results already recorded, and expressed in any system of units, may also be expressed in one or other of suggested systems, provided turbidimeter is available so that observation on standard solution may be made.—*H. E. Babbitt*

Use of Membrane Filters in Investigations of Water From Wells. S. L. Petrovich. Gigiena i Sanit., **1952**:6:19. For biol. tests it is suggested that 300-ml, 30-ml, 3-ml, and 0.3-ml vols. of test waters be filtered and filter membranes incubated at 41–3°. Results, interpreted by means of table, elim. need of actual microscopic count for detn. of coli index. Index of under 3 corresponds to neg. growth on all filters, index of over 793 is given for pos. growth on all filters. Intermediate values are tabulated.—*CA*

A Method for Estimating Low Levels of Radioactive Contaminants in Water. A. H. Emmons & R. A. Lauderdale. Nucleonics, **10**:22 (June '52). New column type water monitor combines advantages of measuring low concns. of activity with adaptability for continuous operation. For use as continuous monitor, unit could consist of 2 columns; when one is operating as beta-gamma monitor, other is being regenerated. —*PHEA*

New Device, Wider Concept Helps to Measure Odors Quantitatively. V. E. Gex & J. P. Snyder. Chem. Eng., **59**:200 ('52). Technique and operating unit for quantitative measurement of odors is described. Measurement is based on sense of smell of operator and operates from dil. side of threshold point, using clean, fresh air as diluent to gas being sampled. Intensities from necessary dilns. of 500:1 down to 1:1 can be measured, although more concentrated odors require special valving for accuracy. Unit is primarily controlled mixing valve which dilutes continuous flow of sampled gas with continuous flow of clean air, ratio of two being adjusted from excess of diluent back to threshold point. Unit makes no distinction between types of odors, requires power supply, is expensive to build, gives some trouble when moisture contents are high, and is subject to usual variability from person to person.—*PHEA*

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

Safety in Water Works. W. R. LaDue. Wtr. & Sew. Wks., **100**:89 (Mar. '53).

Legal Aspects of Water Fluoridation. W. H. Bell. Modern Sanitation, **5**:3:61 (Mar. '53).

Broken Hill Water Supply. H. B. Fletcher. W.W. Eng., **106**:198 (Mar. '53).

Three Problems at Des Moines Solved by New Filter Plant. D. L. Maffitt. W.W. Eng., **106**:196 (Mar. '53).

Miami in the *Lime*light. C. F. Wertz. Wtr. & Sew. Wks., **100**:98 (Mar. '53).

Dechlorination Linked to Corrosion in Water Distribution Systems. D. B. Williams. Wtr. & Sew. Wks., **100**:106 (Mar. '53).

Breakpoint Takes Over the Load. Harold Dean. Am. City, **68**:3:86 (Mar. '53).

Phoenix Averts a Water Famine. Dean Smith. Pub. Wks., p. 73 (Feb. '53).

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A large mid-western city recently was faced with this problem. Within eight years after the water treatment plant was placed in operation, the submerged steel showed active corrosion of alarming proportions — the warning of a possible loss of a quarter million dollar investment. Various coatings were tested for possible application, but none of those tested was considered satisfactory.

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(Continued from page 50 P&R)

Krickery is what they're talking about in the Northeast these days—tribute to and trouble for Dr. Irving P. Krick of Water Resources Development Corp., whose rainmaking activities in the Southwest and Far West are being blamed for the overabundance of precipitation in this area throughout the past winter and spring. What with an all-time rainfall record for March already on the books and a new one for April now being poured, the drenched and depressed denizens of New England, New York, and New Jersey are muttering in their beards about the inescapable aftereffects of irresponsible cloud seeding. About the only thing that has been saving Dr. Krick from a fate worse than drought has been the coincident possibility that all the A-bomb activity in Nevada has really been the cause. Meanwhile reservoirs are overflowing all over the place and the only way water works men have kept their worrying apparatus in condition has been by fearing that too much now will be not enough soon. Be it krickery, atomics, or just plain rain, the Northeast is all wet.

Safety first is a laudable order of priority, but the Oregon legislature may have been just a wee bit overanxious in this phrasing of its House Bill 257:

> No person shall drill, dig, or otherwise excavate, or have drilled, dug, or excavated any well or hole more than 10 feet in depth and less than 10 or more than six inches in diameter without first completely filling the well or hole from its bottom to the surface.

(Continued on page 92 P&R)

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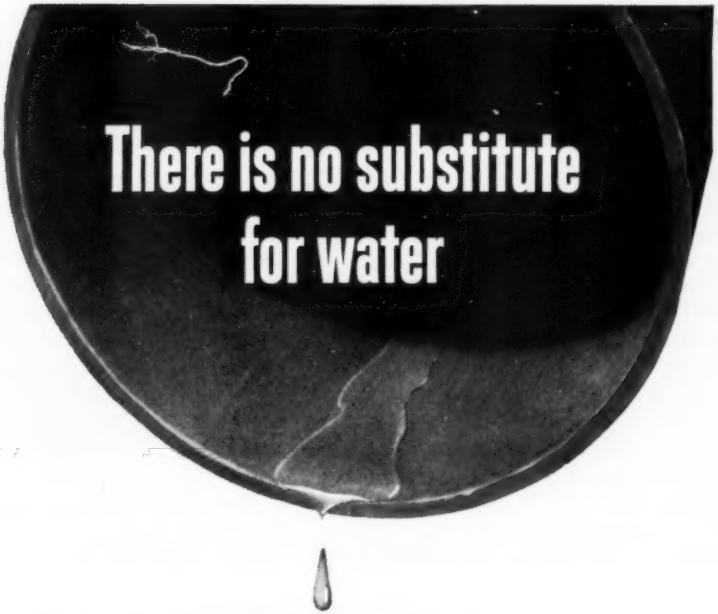

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(Continued from page 90 P&R)

Our TV qui vive to water superintendents had scarcely been uttered and certainly not been heard last month (P&R p. 33) when proof that it had been heeded began to arrive. First a note in the March issue of *Sparling Metrograms* calling on some genius to "devise a system of program evaluation by water loading rating." Then, on its very heels, an answer to the call by George Van Dorp, Toledo, Ohio, water commissioner, who spread equations, curves, and tables all over the March issue of *Public Works* in describing his "water use method," called "W" for short. And almost simultaneously came word from the Illinois Section noting that its March meeting program included a paper on "Judging Radio-TV Programs via Water Consumption," by James L. Weeks, mechanical engineer in charge of the Chicago water department's operating division.

Out of all this interest and industry ought to come something really good—and by good, of course, we mean something that will permit the water works industry to make a buck. Meanwhile, the acid test of water rating is bound to come late this month when Dean Thorndike Saville and Harry Jordan discuss the water resources problem on the "Better Living Television Theater" of the American Broadcasting Company.

E. J. Hall has been appointed western sales representative of Kraloy Plastic Pipe Co., Inc., of Los Angeles.

(Continued on page 94 P&R)

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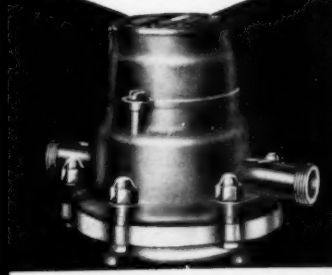

Buffalo AMERICAN Meters are simply designed, with fewer working parts — save money for you through lower maintenance and replacement costs. Write for details.

BUFFALO METER COMPANY
2914 Main Street
Buffalo 14, New York

MUNICIPAL SUPPLIES

TRAFFIC SIGNALS
WATERWORKS
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FIRE EQUIPMENT

W. S. DARLEY & CO.
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No 148

WRITE TODAY
For
100 PAGE CATALOG
W. S. DARLEY & CO. Chicago 12

Joints are few

and far between here

They can be 50 feet apart, to be exact. That's because Armco Welded Steel Pipe is usually supplied in long, 50-foot lengths that simplify handling and hauling. And with fewer joints to make, installation costs drop and the job hurries along.

With the wide range of diameters (6 to 36 inches) and wall thicknesses (9/64- to 1/2-inch) it is easy to meet capacity and strength requirements for your supply line, force main or water works piping.

Armco Pipe also offers a combination of ample strength with ductility. This means that it will resist pressure surges and absorb the impact of heavy loads without damage. Outside coatings are supplied to meet A.W.W.A. specifications; a spun enamel lining will prevent tuberculation.

Write us for more details on time- and money-saving Armco Welded Steel Pipe. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 2843 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

Armco Welded Steel Pipe

ARMCO

Meets A.W.W.A. Specifications

(Continued from page 92 P&R)

How time flies seems more and more frequently brought to our attention, if not actually thrown in our face, as the world hangs on the brink of atomicism and spatiality. Yet it is less the earth-shaking revelations of nuclear physicists and the earth-forsaking peregrinations of uranological telescopists than the turn of ordinary, everyday events that has us too often "remembering when."

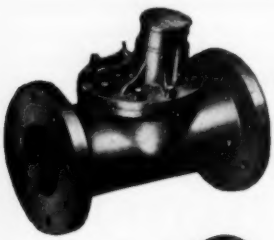
First of a series of recent rather grueling harkbacks was word from Rockwell Mfg. Co. that it had purchased "a new seven-passenger S-55 Sikorsky helicopter" to transport "executives, staff members, and manufacturing components required on an emergency basis between its facilities in western Pennsylvania and throughout the state of Ohio." By placing seven of its outlying plants within easy drop-in distance of the main office at Pittsburgh, the Rockwell organization has claimed that its helicopter provides an effective, modern management tool. But the thought of handy "heliports" in plant parking lots has us almost as busy looking in our hair for evidences of silver as it must have Rockwell plant managers looking in the air for evidences of brass.

Almost simultaneously, a national gathering of Worthington Corp. executives arrived at the disenchanting conclusion that "within the next five to eight years, women must be expected to play an increasingly important role in key engineering and technical capacities." It must, indeed, be the chivalry of an "old fool" that makes us dread the day when a woman's designs are directed at better filtration rather than a better filtration superintendent or when some sweet young thing starts haunting us with hydraulics.

A little less decrepitating than helicopters and engineeresses has been the news of such other revolutions as concrete swimming pools at $130, plastic bathtubs weighing a mere 18 lb, or even the Kansas City suburban sewage plant indistinguishable from the $20,000-and-up homes which surround it. Of course, we must admit, too, that current peace maneuvers, together with at least some vestige of response to spring, have renewed our urge to look ahead to the "good new days"—even though they mean slide rule salads and helicopter housekeeping.

Preload Engineers, Inc., has been formed out of Preload Co., Inc., by Curzon Dobell, E. H. Thwaits, Cedric C. Stainer, and Eric Molke as an engineering firm concerned solely with prestressed structures. The firm is at 955 N. Monroe St., Arlington, Va.

(Continued on page 96 P&R)



Flanged Tube Meters 2" to 36"

SPARLING METERS
***for all* MAIN-LINES**

For instance, at left is shown a meter for main lines as small as 2-inch! Whatever your problem in main-line metering, consult Bulletin 312. A copy is yours for the asking.

SPARLING METER COMPANY

LOS ANGELES — NEW YORK — CINCINNATI — BOSTON
SEATTLE — ATLANTA — DALLAS — KANSAS CITY

How Hallandale, Florida, got Soft, Clear Water

PROBLEM

Well water with hardness of over 240 ppm--mostly bicarbonate--and objectionable organic color. Softening and color removal definitely required. Water Conditioning equipment to be economical in serving today's 5,000 population ... to retain this economy in providing 1980's population with 2,000,000 gpd.

SOLUTION

Briley, Wild & Associates, Consulting Engineers, Daytona Beach, Fla., studied latest methods & equipment. Selected lime-alum method. Specified modern type unit for highly efficient reaction between minerals in water and lime-alum. Installed--Permutit Vertical Precipitator. Upward filtration through suspended sludge blanket gives intimate chemical contact, makes for operating economy.

RESULTS

Softened, clear water. Permutit Precipitator removes color and reduces hardness to desired level. Last traces of turbidity are removed by filtration through gravity filters.

For full information write to THE PERMUTIT COMPANY, DEPT. JA-5, 330 WEST 42nd STREET, NEW YORK 36, N. Y., or to Permutit Company of Canada, Ltd., 6975 Jeanne Mance Street, Montreal.

WATER CONDITIONING HEADQUARTERS FOR 40 YEARS

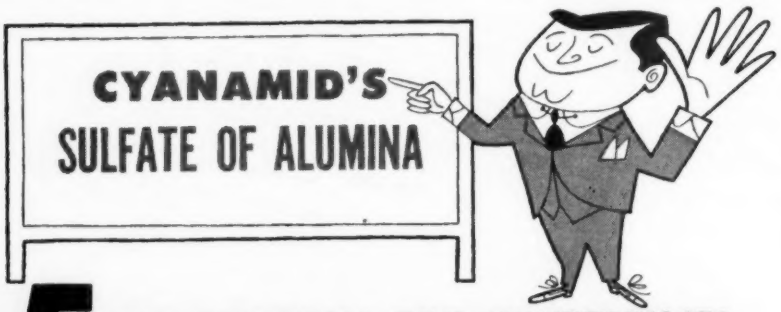
PERMUTIT®

(Continued from page 94 P&R)

Bleeding to death was the condition of Brookfield, Ill., in 1947, when the village of 13,000 was $738,000 in debt and had a bank account of $3,000. And the bleeding was through water mains so leaky that the water department was selling only 43 per cent of the high-priced water it purchased from Chicago for local distribution. It was the citizens themselves who finally had to take matters in their hands by setting up a council-manager system and then working with it to get the town back on its feet. Thus, four years later, through such measures as increasing water rates to permit proper maintenance of the system, Brookfield's debts were down 36 per cent, salaries were up, taxes were unchanged, and the water department was selling 80 per cent of its supply and working hard to cut down the last 20 per cent unaccounted for. That's what led to Brookfield's selection as one of *Look* magazines 1952 All-American Cities—leaky water mains, that is.

A complete line of high-impact styrene plastic pipe in sizes from ½ to 6 in. OD, with threaded fittings in sizes up to 2 in., is being offered by Atlas Mineral Products Co. to supplement the Ampcoflex rigid polyvinyl line already being produced. The new line has been given the trade name Ampcolite, and is available in 10- and 20-ft lengths. It is also being offered with Plastaloy armoring, thus offering a combination of thermoplastic and thermosetting plastics for maximum impact resistance.

(Continued on page 98 P&R)



5 BIG REASONS FOR PREFERENCE!

Waterworks superintendents who depend on Cyanamid's Sulfate of Alumina know these five big reasons for its widespread use:

1. **Uniform, trouble-free feeding**
2. **Wide pH range of coagulation**
3. **Rapid floc formation**
4. **Maximum adsorption of suspended and colloidal impurities**
5. **Minimum corrosion of feeding equipment**

Write today for all the details on how these advantages can help you.

AMERICAN Cyanamid COMPANY
Heavy Chemicals Department
30 Rockefeller Plaza, New York 20, N. Y.
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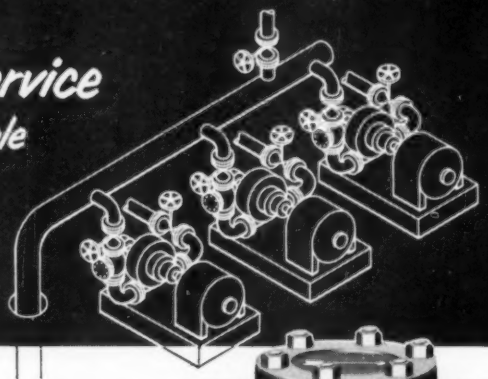
It's not what you Pay for Valves ...it's what they Cost you

on Water Service for example

(A Case History)

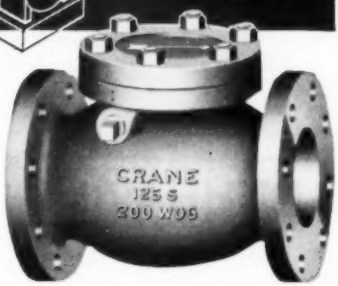


What you pay for valves is not the final criterion of value. Not when maintenance costs can quickly equal or exceed purchase price. And a valve that threatens production is no bargain at any price . . . no attraction to a thrifty buyer.

Take this case in a large eastern paper mill. A single bank of water pumps supplied the entire mill. Leaky check valves at these pumps were a constant problem. Regularly, the checks needed replacement, only to be found leaking between pumping cycles a few months later.

A change-over to Crane Quality Check Valves put a complete stop to this costly maintenance and threat to production. Installed well over a year, Crane checks are protecting the mill against loss of water pressure at no added cost.

Today, more than ever, you need greater assurance of quality in piping materials. You get it in Crane Valves—the recognized standard of quality with thrifty buyers in every industry.



Crane Check Valves are made in all types, in brass, iron, steel, and alloys. See your big Crane Catalog for complete selections in all types of valves. And keep in mind your Crane Representative is always ready to work with you.

CRANE VALVES

CRANE CO., *General Offices:* 836 S. Michigan Ave., Chicago 5, Ill.
Branches and Wholesalers Serving All Industrial Areas

VALVES • FITTINGS • PIPE • PLUMBING • HEATING

(*Continued from page 96 P&R*)

Leslie P. Sharpe has resigned as vice-president of the Ohio Water Service Co. to accept a similar post with the recently organized firm of Owing's-Sharpe, Inc., of Magnolia, Ark.

Earl H. Bradley, executive vice-president of Builders Iron Foundry, has been elected president to succeed Henry S. Chafee, who is stepping down to resume his old post of treasurer of the company. Bradley has been with the Builders group of companies since 1934 as shop superintendent, general superintendent, works manager, vice-president, and, since 1949, executive vice-president. Chafee was previously treasurer from 1930 to 1944, in which year he was elected president.

Also announced was the election of George W. Kelsey as president of Builders-Providence, Inc., instrument division of the Builders organization.

Ross L. Dobbin has retired as general manager of the Peterborough, Ont., Utilities Com., effective March 31, and is being succeeded by W. Howard Powell. A past president of AWWA, Honorary Member, Diven Medal winner and chairman of the Constitution and By-Laws Committee, Dobbin has completed a period of long and useful service to his community and, in addition, to the profession in general.

Erich Hausmann, formerly dean of engineering at Brooklyn Polytechnic Inst., has become associated with the Buffalo, N.Y., engineering firm of Nussbaumer, Clarke & Velzy as a consultant.

(*Continued on page 100 P&R*)

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(Reg. U. S. Pat. Off.)

As a Modern Filter Medium Has Outstanding Advantages Over Sand & Quartz Media

1. Length of filter runs doubled
2. Only about one half as much wash water required
3. Less coating, caking or balling with mud, lime, iron or manganese
4. Filters out of service less because of shorter wash cycle
5. Better removal of bacteria, micro-organic matter, taste and odor
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representing

Anthracite Equipment Corporation
Anthracite Institute Building,
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AMONG WATER WORKS MEN

THE HEAVY-DUTY ELLIS PIPE CUTTER IS *BEST*

FOR CUTTING LARGE SIZES OF PIPE

No. 01 Cuts Pipe 4" to 8"

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Write for circular and price list No. 35J, on our complete line of pipe cutting tools.

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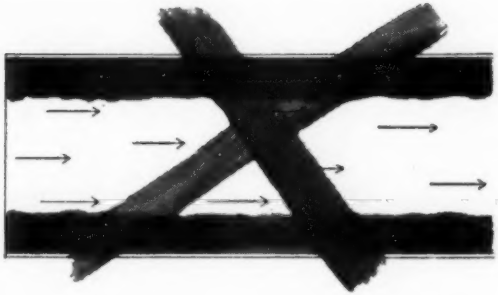
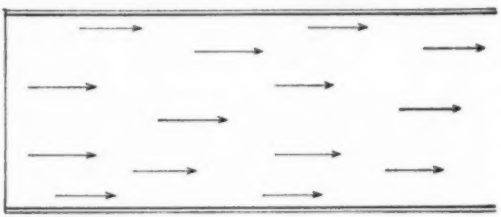
Yes--



flow capacity stays high



...when you protect pipe lines with BITUMASTIC® 70-B ENAMEL

PIPE LINES don't "shrink" when they are lined with Bitumastic 70-B Enamel . . . because this durable enamel prevents rust, corrosion, incrustation and tuberculation. When your pipe line's coefficient of flow *stays* high, there's no need to spend money on *over-sized* pipe in order to allow for future loss in flow capacity.

Further, there's no need to specify a wall thickness any greater than that required to give the pipe adequate structural strength. Because Bitumastic 70-B Enamel—when applied to a thickness of 3/32" — protects the exterior of pipe against the corrosive action of the soil in which it is buried. Therefore it isn't necessary to specify pipe with greater wall thickness in order to compensate for corrosion.

Summed up, Bitumastic 70-B Enamel saves money in two ways. For your large-diameter water lines, you can specify pipe with smaller inside diameter and with less wall thickness. Use strong, durable steel pipe, lined and coated with Bitumastic 70-B Enamel, and give your community these worth-while savings. Write for full information.

KOPPERS BITUMASTIC ENAMELS

KOPPERS COMPANY, INC., Tar Products Division, Dept. 505-T, Pittsburgh 19, Pa.

District Offices: Boston, Chicago, Los Angeles, New York, Pittsburgh, and Woodward, Alabama

(Continued from page 98 P&R)

L. A. Dixon Jr., executive vice-president of Rockwell Mfg. Co., has just been assigned the supervision of the company's Power Tool Div., which includes three tool-making subsidiaries. Dixon retains his responsibility for manufacture and sales of products of the Meter and Valve Div.

Paul C. Kreuch, formerly district and then regional sales manager for Rockwell Mfg. Co., has been appointed assistant to the vice-president in charge of sales, and in that capacity will be responsible to L. A. Dixon Jr. for Meter & Valve Div. sales. Manufacturing supervision has been assigned to Courtney C. Shenkle. Other appointments announced include that of Carl C. Moore, Pittsburgh district manager, as central regional manager of sales, and William S. Andrews, New York district manager, as Pittsburgh district manager.

Edwin B. Cobb, project engineer of Metcalf & Eddy, has been admitted, along with John S. Bethel Jr., into partnership in the Boston consulting firm.

Arthur H. Plautz, sanitary engineer with the Indiana Board of Health, has joined the Indianapolis consulting firm of Clyde E. Williams & Assoc. Other accessions to the firm include August W. Compton, district airport engineer with the CAA, and Thomas J. Driscoll, office engineer with the Portland Cement Assn.

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SODIUM FLUOSILICATE
(Silico Fluoride)
Inquiries Invited
TENNESSEE TC CORPORATION
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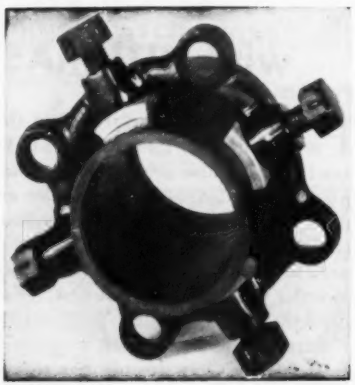

ANCHORED CLAMP for MECHANICAL JOINTS
Also CI-60 charcoal cast iron bolts for mechanical joints; bell-joint Leak Clamps and Gasket Sealer Compound.
Write for information
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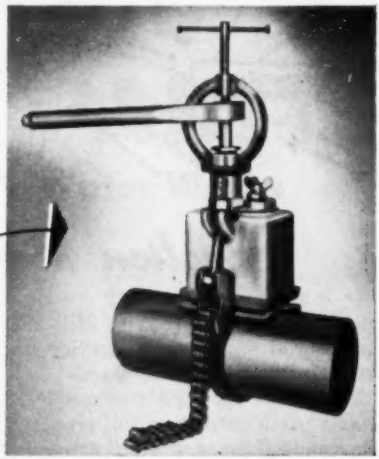
It's new... and better!



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WELSBACH
Kitson
CORPORATION TAPPING MACHINE

For installing corporation stops under pressure, this is the safest, surest, most easily-handled and, without sacrifice of inherent strength, the lightest corporation tapping machine ever made. It is so compact that it is ideal for making taps where space is limited.

It is the new Welsbach-*Kitson* Corporation Tapping Machine—an improved model of the popular Smith-Shelly Tapping Machine, equipped now with a flat chain and adaptor that provides positive non-slip pipe-gripping action . . . which makes it an even better machine than before. And in keeping with the simplicity of operation of this popular machine, the new adaptor, which gives *positive* pipe-gripping action, is easy to set and helps speed the operation.

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POSITIVE, NON-SLIP
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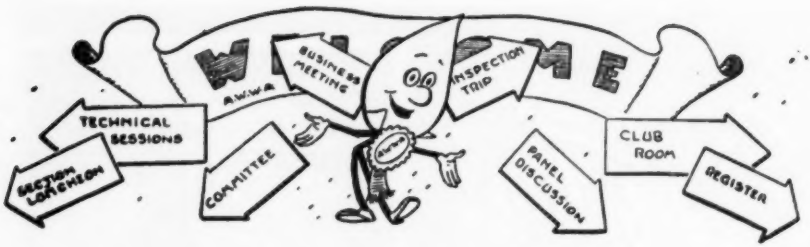


Section Meeting Reports

Southeastern Section: The 24th annual meeting of the Southeastern Section was held at Hotel Dempsey, Macon, Ga., Mar. 23–25. The 205 registered members and guests participated in a full program of technical, business, and social activities arranged by Emory C. Matthews, secretary of the Macon Board of Water Commissioners, host for this meeting; T. A. Jones, superintendent, Water Dept., Fort Valley, Ga., chairman of the Program Committee; and others.

Chairman T. M. Rogers opened the meeting Monday morning and Lewis B. Wilson, mayor, welcomed the group to Macon, promising the wholehearted support of his city in making the meeting a pleasant occasion for all—a promise carried out in every respect, as later events revealed.

AWWA President-Elect M. B. Cunningham spoke at a luncheon Monday noon on various activities of the Association.

Technical sessions were held on Monday, Tuesday, and Wednesday mornings and on Tuesday afternoon. An inspection tour of Macon industries and the city water purification plant was conducted Monday afternoon.

At the Monday technical session, general manager Paul Weir and construction superintendent Roy Ruggles of the Atlanta Water Works discussed the solution of distribution system expansion problems brought on by enlarging Atlanta's incorporated area more than threefold from 37 to 118 sq miles.

Opening the Tuesday program, W. H. Weaver, manager, DeKalb County Water System; Francis B. McDowell Jr., manager, and John R. Bettis, assistant manager, Public Works Dept., Charleston, S.C., related the effects of highway construction and relocation upon local water works departments.

Speaking on manganese and its removal, Robert S. Ingols, Engineering Experiment Station, Georgia Inst. of Technology, and Lamar Futral, superintendent of filtration, Newnan, Ga., outlined the problems and related certain observations Mr. Futral had made over the past several years concerning the effects of copper sulfate in removing manganese from the Newnan water.

Lowell Cady, Wiedeman & Singleton, Atlanta, Ga.; Clyde Angle, Celanese Corp. of America, Rome, Ga.; and others; spoke on different aspects of the subject.

The matter of public relations was covered by C. N. Wallace Jr., Georgia Power Co., Atlanta, Ga., who enumerated experiences and policies of his company which might prove beneficial to water works men.

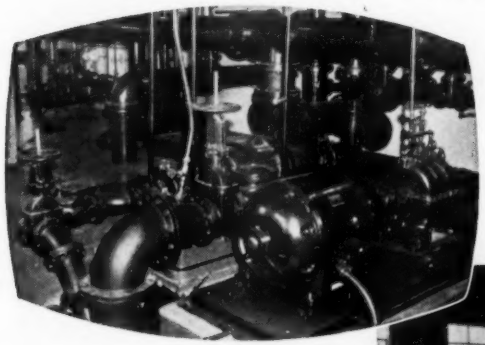
The afternoon session included a talk on "Distribution System Surveys and Conservation" by W. D. Hudson of the Pitometer Co., New York; "Uprating Distribution Systems by Water Main Cleaning" by J. A. Frank, National Water Main Cleaning Co., New York; a technicolor film on the manufacture of cast-iron pipe was presented by Cast Iron Pipe Research Assn., Chicago; and N. M. deJar-

(*Continued on page 104*)

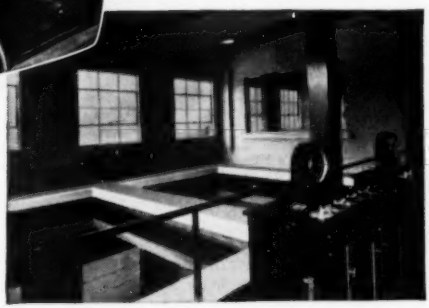
Consulting Engineer L. E. Wooten
specifies

INERTOL PAINTS

for Southern Pines Water Works



Piping, railings and machinery stay safe and attractive with Glamortex, an alkyd resin enamel. On steel or wood, Glamortex imparts a glossy mar-resistant finish. Settling Tanks (not shown) get Torex Enamel, developed for submerged concrete surfaces.



Walls, floors and ceilings take Ramuc Utility, a tile-like rubber-based enamel. Walls of filter beds are protected by Torex Enamel. Torex's pore-free surface prevents mud-ball formation . . . is unaffected by water, chlorine or soda ash.

Long-wearing Inertol Coatings specified throughout plant by Raleigh, N. C., Engineering Company

Coatings used at this modern water works had to more than surpass Engineer Wooten's standards for inertness, elasticity, hardness and water-resistance. On each count—Inertol coatings made the grade. Developed especially for water works application, Inertol Paints provide the long-run economy customers appreciate. Right now, Inertol Paints are doing a satisfactory job in thousands of key installations. Contractors Boyd and Goforth of Charlotte, N. C., found Inertol coatings easy to apply . . . and economical.

An Inertol Field Technician will select the Inertol coatings needed to solve your painting problem. Or write today for our free informative "Painting Guide." You'll want one if you're a Specification Writer, Design Engineer, Plant Superintendent or Contractor.

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Section Meetings

(Continued from page 102)

nette, Georgia Dept. of Public Health, concluded the session with a paper on stream pollution problems, urging water works men to take a more active part in stream conservation.

The entire technical session on Wednesday was devoted to fluoridation. Robert E. Stiemke, director of civil engineering at the Georgia Inst. of Technology, introduced the subject, briefly reviewed the history of fluoridation and deplored the unscientific, untrue, and misleading tactics resorted to by extremists.

W. H. Weaver, manager, DeKalb County Water System, the first water works to begin application of fluoride in Georgia, and Robert Wingard, superintendent, Ninety-Six, S.C., the first in South Carolina; H. L. Dooly, Gainesville, Georgia; John Pearson, Orangeburg, S.C., and others related experiences in their respective plants. No one reported undue difficulties, or complaints which had proven justifiable.

At the business session a resolution was adopted favoring legislation requiring highway departments to assume more responsibility for the expenses incurred by water departments due to highway construction.

John L. Hawkins, superintendent of the Water Dept., Greenville, S.C., was nominated to receive the Fuller Award at the 1953 national meeting.

The following officers were elected: Chairman, Emory C. Matthews; Vice-Chairman, W. C. Bowen; Trustee for South Carolina, Carl C. Lanford; and Secretary-Treasurer, N. M. deJarnette.

Social functions included a buffet dinner at the Idle Hour Country Club Monday evening, when the members and their wives were guests of the Macon Water Dept.; club room refreshments each evening as guests of the Water & Sewage Works Manufacturers Assn., and a dinner and dance at the hotel on Tuesday evening.

The visiting ladies were most graciously entertained at several additional functions by the local committee, of which Mrs. Emory C. Matthews was chairman.

N. M. DEJARNETTE,
Secretary-Treasurer

The 35th Short School of the Texas Water & Sewage Works Assn., held at Texas A&M College Mar. 8–12, rolled up a record registration of 755, proving again that Texas does things on a large scale. The school was held in cooperation with the State Dept. of Health, the Southwest Section AWWA, and the State Board for Vocational Education. Even Nature blessed the proceedings with a daily rain that revived the drought-stricken state, and, according to Mrs. Earl H. Goodwin, assistant secretary-treasurer, the most envied man present was J. E. Williams of San Angelo, who received news that the lake from which his supply was taken was completely filled by a 4-in. rain one night.

In addition to the usual program, a special one-day session was provided for the bottled water industry, and a laboratory demonstration session for water and sewage treatment control. Among speakers at the organizational meetings was Col. M. J. Blew, chief of Water Supply and Sanitary Services Div., Repairs and Utilities Sec., Corps of Engineers, who discussed "Active Participation in Technical Associations as a Means of Self-Advancement." W. H. Wisely discussed trends in sewage treatment and urged his listeners to approach their jobs with pride and enthusiasm. At the AWWA luncheon, Frank S. Taylor, Southwest Section chairman, spoke on the value of AWWA to the water works industry.

Among awards presented at the annual banquet were honorary memberships in the Texas society to Fred H. Puckhaber of Dallas and Roy Matthews of Albany. Awards were also given to the regional associations boasting the best attendance score, the highest percentage of certified water or sewage operators, and the highest percentage of approved public water supplies—this last being won by the Guadalupe Valley Water & Sewage Works. Assn.

We are in our
new factory—
specially designed
to better
our service
and to grow
with your
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If it's concrete . . .

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world's largest manufacturer of concrete sewer and culvert pipe

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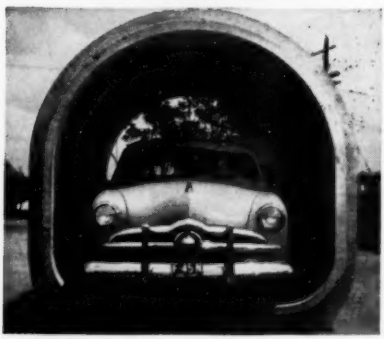
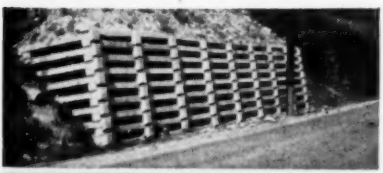


26 plants for convenient, economical service.

30 years' experience in pipe, cribbing, precast manholes, riverweights, flat base pipe. Name it, we make it!



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Columbus, Ohio
Publishers of Famous "Pipe Dreams"

Service Lines

A mercury flow meter for indicating, recording, and totalizing applications is described in Bul. 401 of Simplex Valve & Meter Co., 68th & Upland Sts., Philadelphia 42, Pa. The instrument operates in conjunction with venturi tubes, flow nozzles, or orifice plates.

Multi-circuit float controls which utilize a single float to provide program operation of 2 to 18 circuits are described in a folder, Bul. 3500, on Autocon Type M Selectrols, distributed by the Automatic Control Co., St. Paul 4, Minn.

"Alum"—a 43-page handbook of reference data on commercial aluminum sulfate—is available from the American Cyanamid Co., Industrial Chemicals Div., 30 Rockefeller Plaza, New York 20, N.Y. In addition to providing information on the properties and uses of the compound, sections detail the history of its use and manufacture.

Corrosion-resistant fastenings of the H. M. Harper Co., 8251 Lehigh Ave., Morton Grove, Ill., are illustrated and described in a pocket-size booklet to be had for the asking. Nuts, bolts, screws, rivets, and specials are included.

Laying instructions for prestressed concrete pressure pipe are furnished in a simply written and clearly illustrated handbook intended for the workman and available from the Pressure Pipe Div. of Price Brothers Co., Dayton 1, Ohio. In 14 short pages, how-to-do-it instructions are given for trenching, grade alignment, installing, and jointing the pipe. Photographs and drawings of actual construction procedures aid comprehension.

Now, at a REDUCED PRICE, the accuracy of the loss-in-weight feeding system is available for feeding very small quantities of dry material. Omega's NEW Size "O" Loss-In-Weight Gravimetric Feeder is only about as big as an apartment-sized kitchen range, yet it's capable of feeding up to 100 pounds per hour with an accuracy of 99% or better. Feed rate is adjustable over a 100-to-1 range.

The Size "O" Feeder incorporates all of the Omega Loss-In-Weight features — sentinel alarm to warn of over or under feed, Rotolock mechanism for feeding materials having a tendency to "flood", built-in totalizing counter to check the amount of material fed, and a large five-cubic foot hopper. Write for complete details and price of Omega Size "O" Feeder. Omega Machine Company, 365 Harris Ave., Providence 1, R. I.

OMEGA

B-I-F INDUSTRIES (DIVISION OF B-I-F INDUSTRIES) Ω OMEGA

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Permutit Co.

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Permutit Co.

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Simplex Valve & Meter Co.
Wallace & Tiernan Co., Inc.

Chemists and Engineers:
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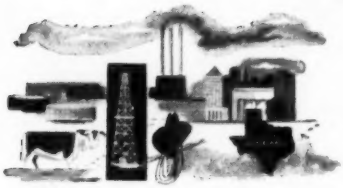
Dallas Prefers Concrete Pressure Pipe



In 1915 Dallas installed the first concrete pressure pipe in its water supply system. Since 1945 several additional miles have been built, and at present a new 23,300 ft. line is under construction.

Dallas engineers prefer concrete pressure pipe because it is easy and economical to install—it requires little or no maintenance—and it has a permanent high carrying capacity. Another important reason for its selection is that water pumped through concrete pressure pipe stays clean—thereby minimizing any odor, taste, and color difficulties.

Like Dallas, many other cities, large and small, are specifying concrete pressure pipe for their water systems. If your city is planning additional water lines, or replacements for old lines, be sure to investigate the advantages of concrete pressure pipe.

Water for Generations to come

Concrete PRESSURE Pipe

AMERICAN CONCRETE PRESSURE PIPE ASSOCIATION
228 North LaSalle Street
Chicago 1, Illinois

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Wallace & Tiernan Co., Inc.

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Think of the increased volume, higher pressure and lower pumping costs that National cleaning will bring to your system—then write or call National today.

There's absolutely no obligation to have National's experienced engineers call.

NATIONAL WATER MAIN CLEANING COMPANY

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Graver Water Conditioning Co.
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Permutit Co.
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Welsbach Corp., Ozone Processes Div.
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Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by A.W.W.A. Associate Members appears in the 1950 Membership Directory.

Part of a 13 mile installation of "Century" Asbestos-Cement Pipe, Lakewood Water District, near Tacoma, Washington

Stock of "Century" Asbestos-Cement Pipe

Water carried 13 trouble-free miles through "CENTURY" asbestos-cement pipe

Near Tacoma, Washington, the Lakewood Water District which serves a very fine residential area recently completed a "Century" Asbestos-Cement water main that will please the taxpayers . . . for generations. For this intimately compacted mixture of two practically indestructible materials—asbestos fiber and portland cement—is so economical to install and so trouble-free in operation that today's money-raising problems are solved, and tomorrow's performance promises kept.

From shipment . . . through piling on the job . . . to eventual cutting-in, this light, exceptionally strong pipe, moderate in cost, is easy to handle. With "Century" Simplex Couplings, curves up to 5° deflection per pipe length can be laid as simply as straight runs, flexural strains caused by earth settlement or trench loading are minimized, and special bends held to a minimum. Labor savings all along the line result.

The economy and complete satisfaction that begin with installation continue down through the years with "Century" Asbestos-Cement Pipe. Because it never tuberculates, its smooth inner surface is permanent, assuring continuous flow with minimum pumping costs. Its outer surface is highly resistant to the corrosive effects of any soil.

Whether or not you are presently planning to buy or specify pipe for water mains, learn more about "Century" Asbestos-Cement Pipe.

Write for FREE BOOKLET, "Mains without Maintenance". Gives valuable data, specifications, and reference material for anyone interested in water main pipes.

Nature made Asbestos . . . Keasbey & Mattison has made it serve mankind since 1873

K&M best in asbestos

KEASBEY & MATTISON

COMPANY • AMBLER

PENNSYLVANIA

The Symbol for Service, Quality and Performance in Water Meters

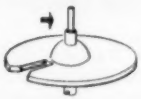
The Extra Value of STAINLESS STEEL TRIM in all Rockwell Disc Meters

TROPIC TYPE
All-bronze, split case construction

ARCTIC TYPE
A bronze meter with breakable frost bottom

ALL THESE VITAL PARTS NOW STAINLESS STEEL

DISC SPINDLE . . .



DIAL FACE ON STRAIGHT READING REGISTER . . . . .

GEAR TRAIN SCREWS

DIVISION PLATE . . .

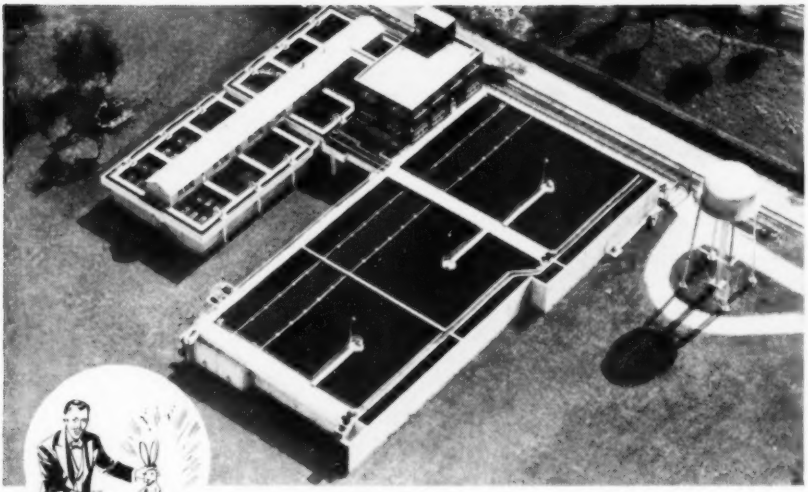
STUFFING BOX SPINDLE

DRIVING DOG . . . .

You can't beat stainless steel for corrosion resistance and durability. That's why you find stainless used in Rockwell Disc meters wherever these superior qualities are required. It's just another indication of the high standards that Rockwell engineers into meters—another reason why Rockwell meters last longer and are so economical to repair.

ROCKWELL MANUFACTURING COMPANY

PITTSBURGH 8, PA., • Atlanta • Boston • Chicago • Houston • Kansas City
Los Angeles • New York • Pittsburgh • San Francisco • Seattle • Tulsa



There's No "Magic Formula"

Every water treatment problem is different

No two water treatment problems are exactly alike. To get the best — and most economical — answer to your specific problem requires careful analysis of raw water composition, rate of flow and the results you require.

There *is* no magic formula . . . no single equipment unit that will give ideal results under all conditions. That's why it will pay you to check both conventional and high-rate units on every water treatment problem.

For a brief picture of the complete Dorr equipment line ask for Bulletin #9141. The Dorr Company, Stamford, Conn.

Repeat order in 1950 "proves out" a "conventional" installation made in 1948.

Quick facts about the Dorrco installation at the
Hollingsworth & Whitney Co., Chickasaw Mills, Mobile, Alabama

1948 . . . First order installed with a design capacity of 10 MGD: 2 Dorrco Flash Mixers, 1 Dorrco Flocculator, 1 Dorrco Squarex Clarifier, 85′ square.

Operating Results . . . Raw water: Color — 65-70 ppm, Raw water: Turbidity — 3.5-3.9 ppm, Finished water: Color — 3 ppm (Dosage in ppm: Alum 20, Soda Ash 15, Chlorine 3 to 5)

1950 . . . Second order installed with design capacity of 16 MGD (Total design capacity: 26 MGD): 1 Dorrco Flash Mixer, 2 Dorrco Flocculators, 2 Dorrco Squarex Clarifiers, 75′ square.

Flocculator and Squarex are trademarks of THE DORR COMPANY — Reg. U. S. Pat. Off.

Every day, nearly 8 billion gallons of water are treated by DORR equipment.

Better tools TODAY to meet tomorrow's demand

DORRCO

DORR

WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT

THE DORR COMPANY • ENGINEERS • STAMFORD, CONN.

Offices, Associated Companies or Representatives in principal cities of the world.

LEADITE

Trade Mark Registered U. S. Pat. Office

Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking